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BALD EAGLE (*Haliaeetus leucocephalus alaskanus*) NESTING RELATED TO FORESTRY IN SOUTHEASTERN ALASKA

A

THESIS

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Patrick O. Corr, B.S.

College, Alaska

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BALD EAGLE (Haliaeetus leucocephalus alaskanus) NESTING RELATED TO FORESTRY IN SOUTHEASTERN ALASKA

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ABSTRACT

There were 136 nests located by aerial survey along 225 miles of beach in six logged plots and six virgin plots. Nest densities during the three years were 0.20, 0.23, and 0.20 active nests per beach mile. Islets present within 2 miles of a logged main shore provided nesting territories for eagles not able to find suitable nest sites along the logged shore. Spatial distribution of active nests indicated a 1.25 mile territory radius per nesting pair. Statistical comparison (Mann and Whitney U test) of mean territory size found in logged versus virgin plots showed no significant difference in territory size between the two plot types. Nests located in beach fringe timber remaining after harvesting were utilized frequently because of the lack of alternate nest sites in the immediate vicinity; these nest sites were highly susceptible to wind throw. Storm damage resulted in the loss of 20 per cent of the known nests during winter 1968-1969. It is recommended that buffer zones (10 chain radius - 660 feet) around eagle nests be maintained during harvesting, and that logging activity in the vicinity of nesting eagles be curtailed during April and May. Also, smaller, scattered timber sales should be promoted to ensure that extensive beach strip logging does not remove potential nest sites along miles of shoreline.

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INTRODUCTION

Bald eagle populations (*Haliaeetus leucocephalus leucocephalus* and *H. l. alaskanus*) of the contiguous United States have been declining since the middle to late 1940's. Studies by Broley (1950, 1951, 1952) and Howell (1949, 1954, 1958) first brought this fact to public attention. Later studies by Sprunt and Ligas (1966) have supported earlier observations. Reasons presented by Broley (1957) for the decrease in Florida's west coast eagle population were too many people, too much building (including timber removal), and increased development of coastal land. A later paper (Broley, 1958) expressed concern for reproductive failure due to an unknown environmental pollutant or pollutants. Sprunt and Ligas (1966) gave four reasons for the decrease in eagle populations across the country. First was an increase in human disturbance due to greater population, increased leisure time, and a rapid growth in outdoor recreation, particularly boating. Second was a loss of nesting habitat by removal of potential nest sites through timber harvesting and construction of housing developments and industry in coastal areas. Third was shooting by irresponsible and uninformed persons, and fourth, was strong circumstantial evidence of involvement of environmental pollutants (e.g., DDT, chlordane, and dieldrin). Both of these studies cite logging (removal of potential nest sites) as a reason for decreased eagle populations.

The Tongass National Forest, including almost all of southeastern Alaska, is one of the remaining strongholds of bald eagles. Even though a bounty was paid on bald eagles between 1917 and 1952, the eagle population of the region far exceeds that existing anywhere in the contiguous United States (Imler and Kalmbach, 1955). Recent development of two dissolving pulp mills, demand for timber by local sawmills, and increased export of forest products has resulted in a greatly increased harvest of southeastern Alaska's forest resource. Prior to 1954 and the establishment of Ketchikan Pulp and Paper Company, the forest industry operated almost entirely on Sitka spruce (*Picea sitchensis*) (Sandor and Weisgerber, 1958). The main use was lumber marketed to local communities. Sitka spruce, easily accessible to tidewater, bore the brunt of the harvest resulting in partial cuts leaving residual stands of western hemlock (*Tsuga heteropylla*), cedars (*Chamaecyparis nootkatensis* and *Thuja plicata*), and poor quality Sitka spruce. The total cut for the period 1909-1953 was 1.84 billion board feet as compared to

0.86 billion board feet for the 4.5 years from January 1954 through June 1958. During this latter period the timber cut was 47 per cent of the total cut for the previous 45 years (Rogers, 1960). Establishment of local pulp mills and increased demand for pulpwood after 1954 resulted in abandonment of the previously used harvesting practices. Adoption of large-scale clear cutting involved not only timber stands along beaches and valley bottoms but also stands on steeper slopes (Bishop and Stevens, 1964). This change in harvesting policy and the increase in volume cut have led to concern for the resident eagle population of the Tongass.

This study examines some factors affecting bald eagle breeding populations in southeastern Alaska and the affect of logging on breeding success. Objectives of the study were to census the breeding population of the study area, to obtain data on eaglet production from active nests, to describe factors influencing nest site selection, and to determine the affect, if any, of current forestry practices on the bald eagle population. Information on basic biology and ecology of the species should provide a basis for the development of a sound management policy for southeastern Alaska's eagles.

The study was carried out through the Alaska Cooperative Wildlife Research Unit and the Department of Wildlife and

Fisheries at the University of Alaska, Fairbanks. Financial support was provided through the Institute of Northern Forestry, Juneau, Alaska, and the Alaska Cooperative Wildlife Research Unit. Logistic support, and assistance with field work was provided through the United States Forest Service, Petersburg Ranger District, and the Alaska Department of Fish and Game, Petersburg, Alaska.

LITERATURE REVIEW

There are two races of *Haliaeetus leucocephalus*, the southern bald eagle, *H. l. leucocephalus* (Linnaeus), and the northern bald eagle, *H. l. alascanus* Townsend. Bent (1937) describes the breeding range of the southern race as not extending north of South Carolina, the Gulf States, and southern California. Breeding range of the northern race extends from northwestern Alaska, Mackenzie, Manitoba and southern Ontario, southeastern Quebec and New Foundland, south to the Aleutian Islands, southern Oregon, Idaho, Wyoming, Colorado, South Dakota, Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, and Maryland (Gabrielson and Lincoln 1959).

Bald Eagle Range in Alaska

Gabrielson and Lincoln (1959) present a detailed description of the bald eagle's range in Alaska. They state that bald eagles breed abundantly along the coast and islands from Attu throughout the Aleutians, the Alaska Peninsula, and south and east throughout southeastern Alaska. Many birds appear to wander farther south in colder months, and eagles from interior Alaska move to the coast during winter.

Bald Eagle Research in Alaska

Bald eagle research in Alaska has been directed toward food habits, nesting, and census methods. Imler and Kalmbach (1955) compiled much of the then available knowledge in their comprehensive report. Although primarily a food habits study, general information on nesting, brooding, and legislation affecting eagles was presented. Hensel and Troyer (1964) and Troyer and Hensel (1965) report on bald eagle nesting and population studies on Kodiak Island. Robards and King (1966) present nesting and eaglet production data from southeastern Alaska. King, Robards, and Lensink (1972) conducted a census of breeding bald eagles in southeastern Alaska.

Phenology of Breeding

Bent (1937) has shown that timing of breeding and egg laying varies greatly throughout bald eagle range, but variation within regions is not very great. Fifty per cent (31 of 62) of egg dates from Georgia, Florida, and Texas were between 8 December and 27 January. Over 50 per cent (38 of 75) of egg dates from Virginia to New Jersey ranged from 1 April to 21 April, and 50 per cent (31 of 62) of egg dates from Alaska and Arctic America were between 7 May and 14 May. The median dates of egg laying for Florida, New Jersey, Michigan, and Alaska are roughly

12 January, 3 March, 10 April, and 10 May, respectively (Imler and Kalmbach, 1955).

Nests and Nest Sites

Nests are described by Dixon (1909), Herrick (1924a, 1924b), Smith (1936), Bent (1937), Broley (1947), Hensel and Troyer (1964), Troyer and Hensel (1965), Robards and King (1966), and Mathisen (1968). Materials used in construction of nests and preferred nest sites vary with locality, but the end result is quite similar.

Nests are rebuilt and added to each year and become immense structures after years of use. Herrick (1924b) describes the technique employed by eagles in building their nests and observed sticks up to 3 feet long and 2 inches in diameter being used. Materials used in building the nest were generally picked up from the ground or beaches of the area. Occasionally, sprigs of fresh vegetation (leaves of *Quercus* sp. and *Pinus strobus*) were brought to the nest.

Herrick (1924b) and Broley (1947) state that the size and shape of a nest is largely determined by the supporting branches and thus is correlated with the species of tree involved. A first year nest frequently reaches 5 feet in diameter and 5 feet deep; older nests occasionally are 8 feet in diameter and 10 to

12 feet deep. Broley (1947) found Florida pines (favored nest trees) tend to have deep crotches allowing deep, relatively narrow nests. The largest nest found in these trees was 20 feet deep and 9.5 feet wide. The largest nest Broley found in Ontario was 8 feet wide and 8 feet deep. Elms (Ulmus sp.) were the favored tree species in this area.

Mathisen (1968) summarized differences between eagle nests and osprey nests of the Chippewa National Forest in Minnesota. The critical characteristics involved choice of nest tree, shape and size of nest, position of nest in tree, timber type, and health of nest tree. Eagle nests tended to be flat-topped, cone-shaped, and were generally placed below the tree crown on main branches. The eagle nest trees were almost always located in upland timber and were generally live trees although the top or crown may have been dead. Osprey nests were in dead spruce or tamarack (Larix laricina) located in low-lying areas near potholes or beaver ponds. Osprey nests were also placed at the very top of the tree with little or no cover over them. Osprey nests tended to be ball shaped and sticks were not neatly placed as they were in eagle nests. These observations proved helpful in identification of unoccupied nests in the Great Lakes Region.

Dixon (1909) reports finding few nests in dead trees in southeastern Alaska, and that most nest trees are located 50 yards or more in from the beach. He concluded that nests must be well placed and firmly supported to withstand strong winds and heavy snow loads in winter.

All observers report that nest sites are generally near water. Mathisen (1968) found that 60 per cent of the nests on Chippewa National Forest were within 0.25 mile of open water, 18 per cent between 0.25 and 0.50 mile from open water, 14 per cent between 0.50 and 1 mile from open water, and only 8 per cent were greater than 1 mile from open water. Broley (1947) reported on 147 active nests in Florida, 80 per cent of which were in coastal areas within 2 miles of the beach. The remaining 20 per cent were generally located near small lakes.

Nesting studies of Alaskan eagles have shown a decided preference for nest sites near water. Hensel and Troyer (1964) found fourteen territories at Karluk Lake, Kodiak Island. These territories were determined by measuring the area included within lines connecting favorite perches of adult eagles; they averaged 57 acres and ranged in size from 28 acres to 112 acres with boundaries overlapping. Food gathering and soaring by other eagles was tolerated within a territory. Nest sites used on Kodiak Island were cottonwood trees (prefered), rock cliffs, and bases of alder trees protruding from cliffs. Areas without trees or cliffs were devoid of nests (Troyer and Hensel, 1965).

In a study of eagle nesting in southeastern Alaska, Robards and King (1966) observed eagles around nests in early April, and by May all pairs appeared to be incubating. Eaglets hatched by 7 June, and all young were well-feathered by 7 July. Nests were located near water (occasionally up to 200 yards from the beach). If nests were situated away from the beach, there was always a clear, unobstructed flight path to the water. Greatest nest density was found in areas fronting wide expanses of open water; small confined bays which remained ice bound well into nesting season were not used. Exposure to sun, proximity of salmon streams, and prevailing winds were not found to influence nest site selection.

Census of Southeastern Alaska Eagle Population

An aerial census of bald eagle breeding populations was conducted by King, Robards, and Lensink (1972). A random sample of plots from southeastern Alaska was taken, and the beaches within the plots were flown during late April and early May, 1967. They determined that the bald eagle breeding population of southeastern Alaska was greater than 4,000 pairs. The breeding population in the region south of Sumner Strait was found to be approximately half as dense as that north of Sumner Strait.

Development and Care of Eaglets

Herrick (1932a, 1932b, 1933) describes the early phase of bald eagle life and the development of eaglets from natal down to juvenal plumage. The light natal down remained for a period of 3 weeks before it was replaced by a second down stage that was thicker, shorter, and darker than the natal down. Between 6 and 7 weeks of age the eaglets were in transition to dark juvenal plumage which was complete by an age of 10 to 13 weeks.

Herrick (1924c, 1924d, 1933) also describes the behavior of adult eagles during nest building, egg laying, incubation, and brooding. He identified two periods during which the behavior of the adults was markedly different. During incubation and the approximately 4 weeks after the eaglets hatched, there was generally at least one adult at the nest incubating eggs, or guarding, feeding, and brooding the young. Four weeks after hatching the adults began to use favored perches nearby, and were seldom observed with the young on the nest.

Bald Eagle Food Habits

Observations of eagles pursuing and taking live prey are too numerous to list. Herrick (1924c) and Imler and Kalmbach (1955) summarize observations of hunting techniques, and Southern (1963) describes fishing methods at open holes in frozen rivers. Murie (1940) described food habits of bald eagles in the Aleutian Islands and Imler and Kalmbach (1955) analyzed 435 bald eagle stomachs collected in southeastern Alaska in the vicinity of Petersburg. Nearly two-thirds (65.7 per cent) of the diet of southeastern Alaskan eagles consisted of fish, most of which was considered carrion by the authors. Less than one-fifth of their diet was of avian origin; however, 80.7 per cent of the food of Aleutian Island eagles consisted of scoters and sea birds which were locally abundant. The Aleutian Island food study was done by examining pellets; since pellets are seldom formed when eagles feed exclusively on fish, the importance of fish in their diet was probably underestimated. In Imler and Kalmbach's study (1955) birds were more important elements in the diet of eagles during the winter months.

The larger portion of carrion eaten stems from dead fish found along beaches. Munro (1938) observed that most of the eagle's spring food along the British Columbian coast was taken from sea beaches and boulder reefs at low tide. He found that boulder reefs provide a greater food supply than areas of sand and gravel.

Herrick (1924c) showed that 80 to 90 per cent of food brought to the Vermillion, Ohio nest was fish. In 1922, 70 per cent and in 1923, 96 per cent of food delivered to the nest was fish. He believed that most of the fish was carrion picked up from the surface of Lake Erie or along its shores. In a later paper he stated that one-half or more of the fish delivered to the nest were alive on arrival, and he stated that this may also have been true in earlier years of the study (Herrick, 1933).

Human Disturbance

Hensel and Troyer (1964) express concern that the low nesting success in 1961 (33 per cent) was caused by the greater frequency of their visits to the nest site. Broley (1947) observes that nest abandonment frequently occurred after some disaster (egg collection, loss of young or mate, predation). He also wrote, "It is remarkable how much disturbance may occur around a nest without causing the eagles to desert." This was shown during construction of Dr. Herrick's observation towers in 1923 and 1929, the eagles continued their nest repair and early stages of nest life without deserting their nest.

The effects of human disturbance at eagle nests on the Chippewa National Forest was studied by Mathisen (1968). He concluded that human disturbance, "in degrees now existing", on the Chippewa National Forest is within tolerance limits of nesting eagles. Disturbance due to timber harvesting occurred after eggs were hatched and a strong bond to the nest site was established. Earlier disturbance during egg laying and incubation may be important reasons for nest abandonment (Mathisen, 1970b). United States Forest Service policy prohibits activity within 132 feet of nest trees and a "buffer zone" of 660 feet is provided during the nesting period. Mathisen (1968) concludes that this policy is, "well within limits of tolerance of eagles on Chippewa National Forest".

Broley (1947) reports movement of eagles after extensive logging programs in western Florida from 1941 to 1945. He noted little change in numbers of active nests in an 8 year period except in areas where timber was harvested. As noted earlier, if eagles lost a nest tree or deserted a nest after a disaster, they generally rebuilt close by. In the case of nests in logged areas, the eagles were forced to move 5 to 20 miles inland to lakes or cypress swamps.

Direct or indirect killing of bald eagles results in a significant loss of birds annually. The most recent example of direct killing has been documented in Wyoming where federal charges of conspiracy to kill federally protected birds have been brought against two influential land owners. The charges resulted from the killing of 363 golden eagles, 3 bald eagles, and 7 Canada geese (Sayre, 1972). Indirect killing of eagles also was recently discovered in parts of Wyoming and Colorado where antelope carcasses were loaded with thallium sulfate and used ostensibly in predator-control programs (Callison, 1971).

DESCRIPTION OF THE REGION

Southeastern Alaska is included in Merriam's Canadian Ecological Zone, and is an area of heavy rainfall with the largest trees in Alaska (Gabrielson and Lincoln 1959). The Region consists of a large narrow mainland strip with numerous large and small islands. These form many straits, inlets, passages and bays which offer many miles of coastline. It is over 400 miles long and 100 to 150 miles wide, and covers almost 5 degrees of latitude (55^{o}N - 60^{o}N) and 10 degrees of longitude (130^{o}W - 140^{o}W).

Approximately 22 million acres of land (about one-sixth of the state) are included east of the 141^{st} meridian. Of this acreage, 13,700,000 acres are on the mainland; 67 islands have more than 2,500 acres each, 17 islands exceed 50,000 acres, and 3 islands are larger than 1 million acres. Seventy-three per cent of the land area is in the Tongass National Forest which includes 97 per cent of the commercial forest land in southeastern Alaska. The remaining acreage is in federal, state, and private ownerships. Topography ranges from broad flats and rolling lowlands to rugged, mountains with summits generally 5,000 feet or less, except for higher peaks and extensive ice fields along the mainland (Stephens et al., 1969).

Climate

Southeastern Alaska's climate is cool and wet. Temperatures have a narrow range from cool summers to moderate winters. Mean annual temperatures range from about 38°F to 46°F with average maximum temperatures for July ranging from 60°F to 64°F in different sections of the Region (Patric and Black, 1968).

Rainfall is heavy and well distributed throughout the growing season (Andersen, 1955) with an average of approximately 90 inches annually over the region as a whole (Helmers, 1960). Mean annual precipitation ranges from about 40 inches to over 200 inches (Patric and Black, 1968). The annual precipitation is extremely variable from area to area, due to irregular topography. Annual precipitation at higher elevations is believed to be over 300 inches based on stream runoff data (Stephens et al., 1969).

Snow fall in the Region is moderate in quantity and accumulation at sea level is minimal due to frequent winter rains. First snows occur in the latter part of October; snow disappears at sea level in March or early April, but it is still present at higher elevations well into the summer. Severe storms frequently occur during the winter months. Very strong winds associated with these storms cause much damage in coastal areas.

Vegetation

The climatic climax forest which has developed since Pleistocene ice recession 10,000 years ago is described by Taylor (1932) as an extension of the rain forests of the Pacific Northwest and British Columbia. The forest of the southern region is composed of 73 per cent western hemlock, 23 per cent Sitka spruce, 3 per cent western redcedar, occasional specimens of Alaska cedar, subalpine fir (*Abies lasiocarpa*), and Pacific yew (*Taxus brevifolia*) make up the remainder. Approaching timber line, western hemlock often is replaced by mountain hemlock (*Tsuga mertensiana*) and Alaska cedar is apt to be found in greater abundance. Western redcedar is not found north of the northern shore of Sumner Straight or approximately 56° 30'N latitude (Helmers, 1960). Taylor (1932) also provides a complete list of plant species found in four common habitat types (beach finge, climax forest, open stream banks and meadows, and muskegs).

Lawrence (1958) describes primary succession after ice recession at Glacier Bay and the Juneau Ice Field; this paper describes the development of southeastern Alaska's forests to the present day. Taylor (1932) discusses secondary plant succession after logging, fire, avalanche, wind throw or other factors which open up the climax forest. He found secondary succession resulted in a forest with varying mixtures of Sitka spruce and western hemlock. Taylor showed that subclimax stands from primary succession were less productive than subclimax stands developing from secondary succession. He attributed the better growth to the mixture of spruce and hemlock.

Forestry

Over 90 per cent of the commercial forest land of the Tongass National Forest is an all-aged, over-mature, defective forest of western hemlock and Sitka spruce; only five per cent of the commercial land is in even-aged second growth stands of mixed western hemlock and Sitka spruce resulting from earlier cuttings, wind thrown areas and fires (Sandor and Weisgerber, 1958). Approximately one-half of the gross volume, according to present cutting standards, is cull in the poorer stands and about one-third is cull in the better stands (Godman, 1952). Species of secondary commercial importance are western redcedar, Alaskan cedar, and mountain hemlock.

Forest management prior to 1921 on the Tongass National Forest was primarily custodial with emphasis on protection from fire, trespass, and unwise encroachment (Bruce, 1960).

Between 1924 and 1938, research was conducted on natural regeneration and related silvicultural problems in clear-cutting; the results were used for policy formulation and management. Research work was discontinued in the middle thirties and did not resume until the Alaska Forest Research Center was established in Juneau in 1948.

Attempts to establish a pulp and paper industry were made by the Forest Service prior to 1948, but these projects failed because of economic factors alone (Rogers, 1960). During World War II, defense construction in Alaska resulted in increased harvest and production of lumber from south-eastern Alaska. Also, after the War, interest in Alaska pulpwood revived. An award of a fifty year sale contract to Ketchikan Pulp Company in 1951 and the successful operation of a modern plant since 1954 marked the turning point in forest management on the Tongass National Forest.

The most pressing objective of silviculture on the Tongass National Forest is considered by the Forest Service to be the rapid conversion of over-mature, decadent, uneven-aged stands into young, fast growing forests of high potential value for sawlogs as well as pulpwood. Current Forest Service policy assumes clearcutting to be the only feasible method of harvesting capable of achieving this goal (see Fig. 1).

Fig. 1. A small A-frame logging operation, plot two, 1969.

The increased demand for timber and the overall silvicultural objectives have resulted in drastic changes in harvesting policy. Old methods were confined to small islands and bays and were often unobserved by even local inhabitants. Modern methods of clearcutting large areas, even on steeper slopes, have made forest harvesting obvious to visitors as well as residents of southeastern Alaska. Today's management policy must coordinate the varied and valuable resources of southeastern Alaska (tourism, wildlife, hydroelectric and recreation) with harvesting policy (Rogers, 1960).

MATERIALS AND METHODS

Initial Planning

Initial planning and the 1967 fieldwork were accomplished by Mr. Edward Poulin, graduate student, University of Alaska. The initial plans and methods developed by Poulin were followed by the author in 1968 and 1969 in order to ensure the collection of comparable data.

Selection and Location of Study Plots

Twelve plots were selected within a 40 mile radius of Petersburg. The field work was confined to this area because of transportation limitations imposed by the size of the boat available and its fuel capacity. Six plots (I through VI) were chosen to include a maximum of logged beach frontage; plots VII through XII were selected because of the nearly complete absence of logging in these areas (Appendix II, Map 1).

The study plots were located along the north, east, and south shores of Kupreanof Island, the east and west shores of Duncan Canal (Kupreanof Island), the east and south shores of Mitkof Island, the north shore of Zarembo Island, the west and south shores of Woewodski Island, and the Level Islands. Sumner Strait, Frederick Sound, and Duncan Canal are the main bodies of water bordering the plots. Information on the location, size, and completion date of all logging activity in the area was obtained from Forest Service records at Petersburg and Wrangell. This was plotted on Forest Service quarterquadrangle maps (scale 1:31,680) along with the boundaries of the study plots.

Aerial Survey

The only method which facilitated locating large numbers of eagle nests within the study area was aerial survey. Flights were conducted during June and July of 1967, 1968, and 1969. A Piper Super Cruiser was used in 1967 and 1969; in 1968 it was necessary to use a Cessna 185 (one flight was made by helicopter). Of the three aircraft used, the helicopter was the best suited for observation of eagle nests, but the greater expense and shorter cruising range made its use for this study impractical. The Super Cruiser proved better than the Cessna because of its lower air speed, greater maneuverability, and good visibility afforded both the pilot and observer. Three or four passes were made over the entire beach front. Generally, one pass at low level over the water, one above the beach timber, and one 500 to 600 yards inland were sufficient to locate nests. Once located, nests were approached by air as closely as possible in order to observe contents of the nests. The passes were made at elevations from near tree level to 250 feet at air speeds as low as 55 mph in the Super Cruiser to 75-80 mph in the Cessna. The edge of all logged areas furthest from the beach was searched for nests. The position of all nests located was marked as accurately as possible on the maps to facilitate relocation by boat. This was critical because nests observed easily from the air may be almost totally hidden from the water's surface or the ground. The status of a nest and, when possible, a count of eggs or eaglets present were recorded.

Boat Survey

A sixteen foot wooden skiff powered by a fifty horsepower outboard was used for the ground survey. Because of the small size of the boat, field work was severely hindered by adverse weather and high seas. Nests located by aerial survey were revisited by boat during the remainder of the field season. Adjustments were made to the nest location on the maps if this was needed.

Data Recorded

Status of Nest: The status of a nest was determined by the presence or absense of eggs, eaglets, or incubating and brooding adult eagles. The presence of a large number of droppings around a nest tree was not considered indicative of an active nest. The letter A was recorded if eggs, eaglets, or brooding adults were on the nest; a number following the letter represented the number of eaglets if a positive count was obtained. The letter I denotes an inactive nest; all nests not classified as active were considered inactive even though a pair of adults may have been observed in the vicinity.

Nest Tree: Each nest tree was recorded by species and crown class. The four crown classifications used were: dominant (tree top above the general forest canopy), codominant (tree top in general forest canopy), intermediate (tree top just below and reaching into general forest canopy), and surpressed (tree top below general forest canopy). Height of the nest tree and height to the top of a nest were measured with an Abney level and recorded to the nearest foot.

Nest Site: The following measurements were made at most nest sites: the distance from base of nest tree to shore (feet); the distance from nest tree to nearest logged area (yards); and the width of exposed beach at low tide (yards). Six beach types were identified and recorded by using aerial photographs and ground checks. These categories were: ledge-steep slope, ledge-gentle slope, large rock, gravel and large rock, sand, and mud flat.

Analysis of Data

Distance from nest to logged areas and distance between nests (shoreline and straight line) were determined by direct measurement from quarterquadrangle maps through the use of a map measure. All values were tabulated, and most of the data was coded and entered on edge punch cards to facilitate sorting nests into various categories. Further statistical analysis was utilized where necessary (assignment of confidence intervals and for comparing differences in means).

RESULTS

Description of Study Area

Table 1 is a summary of descriptive data for the 12 study plots presented in Appendix I. There are 224.3 miles of beach included within the 12 plots; of this, 53.5 miles (24 per cent) is adjacent to logged beach frontage and 170.8 miles (76 per cent) fronts on unlogged forest. Appendix II, Map 1, shows the location of the 12 plots. Six study plots (numbers 1-6) were selected to contain a high percentage of logged beach, and six plots (numbers 7-12) were considered

Table 1. Descriptive Data - All Plots

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	94,121	53.48	24.2
Virgin Beach	300,657	170.82	75.8
Total Length	394,778	224.30	100.0
Beach Type:			
Steep Ledge	34,408	19.50	8.7
Gentle Ledge	55,352	31.45	14.0
Large Rock	85,228	48.38	21.6
Gravel-Large Rock	79,244	45.02	20.1
Sand	8,800	5.00	2.2
Mud Flat	131,746	74.95	33.4
Total Length	394,778	224.30	100.0

representative of virgin stands. The degree of logging present in the six logged plots ranged from 24 per cent to

93 per cent of the beach frontage within each plot. In virgin plots the degree of logging present was between 0 and 2 per cent of the beach frontage per plot. Logging and related activity is the only significant land use present in most plots. Other land uses present are discussed in the sections of Appendix I.

Location of Nests

Nest Distribution by Plot: Table 2 shows the total number and percentage of nests found in each of the 12 plots; the total number of nests in logged and virgin plots is also shown. Of the 136 nests observed from the air, 76 nests were located within the six logged plots, and 60 nests were found in the six virgin plots. There are a total

Table 2. Location of Nests by Study Plot

Plot Number	Number of Nests		Per cent	
1	46		33.8	
2	5		3.7	
3	5		3.7	
4	6		4.4	
5	6		4.4	
6	8		5.9	
Subtotal		76		55.9
7	7		5.1	
8	8		5.9	
9	9		6.6	
10	8		5.9	
11	5		3.7	
12	23		16.9	
Subtotal		60		44.1
Total	136		100.0	

of 106.9 miles of beach in the logged plots, and 117.4 miles of beach in the virgin plots for a ratio of 0.71 nests per mile in logged plots versus 0.51 nests per mile in virgin plots.

Plot one, the largest plot (53 miles), contained the greatest number of nests (46 nests), and plot twelve, the second largest plot (28.5 miles) contained 23 nests. These two plots accounted for 69 nests or 51 per cent of the total. The remaining 10 plots contained 67 nests ranging from five to nine nests per plot. Slightly over one-half of the nests were located in 81.5 miles (36.0 per cent) of the total beach frontage. The remaining 67 nests were found in 142.8 miles (64 per cent) of beach frontage.

<u>Nest Distribution by Beach Type</u>: Table 3 shows the number and percentage of nests found in each of the six beach types and the relative percentages of these beach

Table 3. Number of Nests and Relative Percentage of Nests and Beach by Beach Type

Beach Types	Number of Nests	Per cent Nests	Per cent Beach
Steep Ledge	17	12.5	8.7
Gentle Ledge	30	22.2	14.0
Large Rock	39	28.6	21.6
Gravel-Large Rock	24	17.6	20.1
Sand	4	2.8	2.2
Mud Flat	22	16.3	33.4
Totals	136	100.0	100.0

types in the 12 plots. A comparison of percentages of nests and percentages of beach types shows a reasonably good correlation except in the mud flat beach category. In this case the number of nests located in this beach type is lower than expected.

Nest Distribution Versus Logging: Table 4 shows the distribution of 76 nests found in logged plots and their proximity to logged areas. There was a relatively even distribution of nests among the five categories with the largest percentage of nests (27.6 per cent) found in the fringe left at logged areas. Only one of these nests was found in the interior of a logged area, and none were found along the back perimeter of a logged area.

Very few nests were in the category of greater than 1 mile from a logged area. There are 52.4 miles of logged beach and 54.6 miles of undisturbed beach timber in plots one through six. Since the logged areas are scattered along the shores of the plots, there are few points along the shores of these plots which are not within 1 mile of a logged area. Because of this factor, few nests were located greater than 1 mile from a logged area. Similarly, this explains the decreasing percentage of nests within proximity categories as the distance from logged areas increases (refer to Table 4).

Table 4. Location of Nests Related to Logged Area

Plot Number	Within Logged Area	Within $\frac{1}{4}$ Mile of Logged Area	Between $\frac{1}{4}$ and $\frac{1}{2}$ Mile of Logged Area	Between $\frac{1}{2}$ and 1 Mile of Logged Area	Greater Than 1 Mile From Logged Area	Total
1	7	12	12	9	6	46
2	3	0	0	0	2	5
3	3	1	0	1	0	5
4	2	2	0	1	1	6
5	5	1	0	0	0	6
6	1	2	2	1	2	8
Total	21	18	14	12	11	76
Per cent	27.6	23.7	18.4	15.8	14.5	100.0

<u>Nest Distribution by Small Islands</u>: Table 5 shows that 26 of 136 nests (19.1 per cent) were located on small islands (islets). Islets within 2 miles of the main shore were generally included within a plot. In plot one there were 22 islets, 16 of which contained a total of 21 nests (45.6 per cent of plot one nests). Islets were not prevalent adjacent to the shores of the remaining plots.

Table 5. Number of Nests Located on Islets

Plot	Islet Nests	Total Nest	Per cent of Total
1	21	46	45.6
2	0	5	0.0
3	0	5	0.0
4	1	6	16.7
5	1	6	16.7
6	1	8	12.5
7	0	7	0.0
8	0	8	0.0
9	0	9	0.0
10	2	8	25.0
11	0	5	0.0
12	0	23	0.0
Total	26	136	

<u>Nest Density</u>

Nest densities by study plot and year are presented in Appendix III; this information is summarized below in Table 6. The overall nest density of 0.60 nest per beach mile is approximately three times the density of all active nests for each year (0.20, 0.23, and 0.20 nest

Table 6. Summary of Nest Density (nests per beach mile)

Plot Number	Active nests/beach mile 1967	1968	1969	Nests/beach mile (all nests)
1	0.26	0.28	0.17	0.87
2	0.00	0.35	0.17	0.87
3	0.21	0.31	0.21	0.51
4	0.21	0.12	0.25	0.37
5	0.23	0.46	0.12	0.69
6	0.15	0.22	0.22	0.59
7	NS	0.12	0.09	0.24
8	0.16	0.16	0.25	0.66
9	NS	0.34	0.21	0.62
10	NS	0.16	0.11	0.42
11	0.22	0.11	0.22	0.54
12	NS	0.25	0.46	0.81
Overall	0.20	0.23	0.20	0.60

NS = not surveyed

per beach mile in 1967, 1968, and 1969 respectively).

There appears to be a decrease in active nest density in plots one, two, five, and seven between 1968 and 1969; during this same period an increase in active nest density was noted in plots four, eight, and eleven. These changes are reflective of the change in number of breeding pairs per plot discussed in a following section. These plots are close enough to one another to expect some movement of breeding pairs between them.

Nest Status and Production

Nest Status: Appendix IV presents nest status and eaglet production data for all nests and years; Table 7 is a summary of nest status data. The percentage of active nests was greatest in 1968, but the range between the three seasons was small.

Table 7. Summary of Nest Status

Status	1967 Number	1967 Per cent	1968 Number	1968 Per cent	1969 Number	1969 Per cent
Active	28	37.4	51	44.4	47	42.7
Inactive	47	62.6	64	55.6	63	57.3
Total	75	100.0	115	100.0	110	100.0

Loss of Nests: Table 8 shows the loss of nests during the two winters of the study. During the winter of 1967-1968 only two nests (3 per cent of the known nests) were destroyed; in the winter of 1968-1969 there were 23 nests destroyed (20 per cent of the known nests). The destruction of one-fifth of the known nests was a direct result of one severe storm in which gale winds caused great damage to timber in the southern portion of the study area (see Fig. 2).

Table 8. Wind Thrown or Lost Nests

Year	Known Nests	Nests Lost	Per cent Lost
1967 - 1968	75	2	3
1968 - 1969	115	23	20

Fig. 2. Wind-thrown timber near nest site 13, plot four, 1969.

Breeding Pairs per Plot: Table 9 shows the number of pairs nesting in each plot for the three years of the study. A subtotal and average is shown for the eight plots surveyed in the three field seasons, and a total and average for the 12 plots surveyed two seasons is presented. The high average number of pairs per plot was 4.00 in 1968 for the 8 plots surveyed in 1967, 1968, and 1969, and 4.25 for the 12 plots surveyed in 1968 and 1969. The number of pairs per plot remained fairly constant between 1967 and 1968 (only plot eleven showed a decrease); between 1968 and 1969 however, many pairs shifted nesting territories. Six pairs left plot one and three pairs moved from plot five. Increases in the number of pairs found in plot four, eight, and eleven could account for five of these pairs, but it could not be positively established because none of the eagles were marked for identification. Decreases of one pair per plot from plots two, three, seven, nine, and ten almost balance the increase of six pairs in plot twelve. This extensive shift of pairs is believed to stem from the severe storm of 1969 which damaged so many nests. A possible explanation for the relatively large increase of breeding pairs noted in plot twelve lies in the timing of the aerial surveys. In 1968 the plot was flown in July (late in the breeding season). Some active nests may have been deserted, or young from early nesting pairs could have left the nest prior to the survey thus lowering

Table 9. Number of Breeding Pairs by Study Plot and Year.

Plot Number	1967	1968	1969
1	14	15	9
2	0	2	1
3	3	3	2
4	2	2	4
5	3	4	1
6	1	3	3
7	NS	4	3
8	1	2	4
9	NS	5	4
10	NS	3	2
11	2	1	2
12	NS	7	13
Subtotal (Plots 1-6, 8, and 11)	26	32	26
Average	3.25	4.00	3.25
Total (Plots 1-12)		51	48
Average		4.25	4.00

NS - not surveyed in 1967

the count of active nests. In 1969 the survey was conducted in early June when all young would still have been on the nests.

<u>Production per Nest</u>: Table 10 presents a summary of eaglet production data from Appendix IV. The mean for eaglet production ranged from 1.50 to 1.65 eaglets per nest; no nests were observed to have three eaglets. These values represent eaglets counted during aerial surveys, and do not reflect fledglings per nest.

Table 10. Nest Production

Year	Number of Observations	Eaglets Counted	Mean
1967	2	3	1.50
1968	43	71	1.65
1969	36	55	1.53

Nest Activity Index: In order to compare groups of nests an activity index has been calculated for separate categories. The activity index was derived by the ratio of the total number of years the nests within each group were active to the total number of years the nests within the groups were observed. An index of 1.00 indicates that all nests in that group were active each season they were observed; an index of 0.00 shows that none of the nests within that group were active in the seasons they were observed. Activity index values between 1.00 and 0.00 may be converted to percentages in order to relate the actual use of nest sites to the theoretical potential use of 100 per cent. Nests were grouped by plot, beach type, proximity to logged areas, and by occurrence on islets; activity indexes were calculated for the above groups as well as for all nests in logged plots (plots 1-6), all nests in virgin plots (plots 7-12), and for islets as opposed to nests.

Figure 3 represents the indexes calculated for nests in each of the 12 plots. Six plots (three, four, five, seven, nine, and twelve) had indexes above 0.50 which indicates that over 50 per cent of the nests available during the three seasons were utilized. Nests in plot six and near 50 per cent utilization, and available nests in plots one, two, eight, ten, and eleven ranged between 23 and 42 per cent utilization.

Figure 4 shows activity indexes were below 0.50 for nests grouped by beach type, and that they were quite uniform. The indexes ranged from 0.27 to 0.49 with all but one between 0.36 and 0.49. Only 27 per cent of the nests found adjacent to sand beaches were utilized. Variations between activity indexes based on beach type were much less than those based on study plot.

Figure 5 illustrates activity indexes based on the 76 nests found in logged plots and the 60 nests found in virgin plots. The 76 nests located in logged plots were further grouped by proximity to logged areas similar to the categories used in Table 4. The activity index based on the 60 nests in virgin plots (0.47) was higher than that based on logged plots (0.38). Activity indexes based on proximity to logged areas were fairly uniform with the exception of the index based on nests located within a logged area. This indicates that 54 per cent

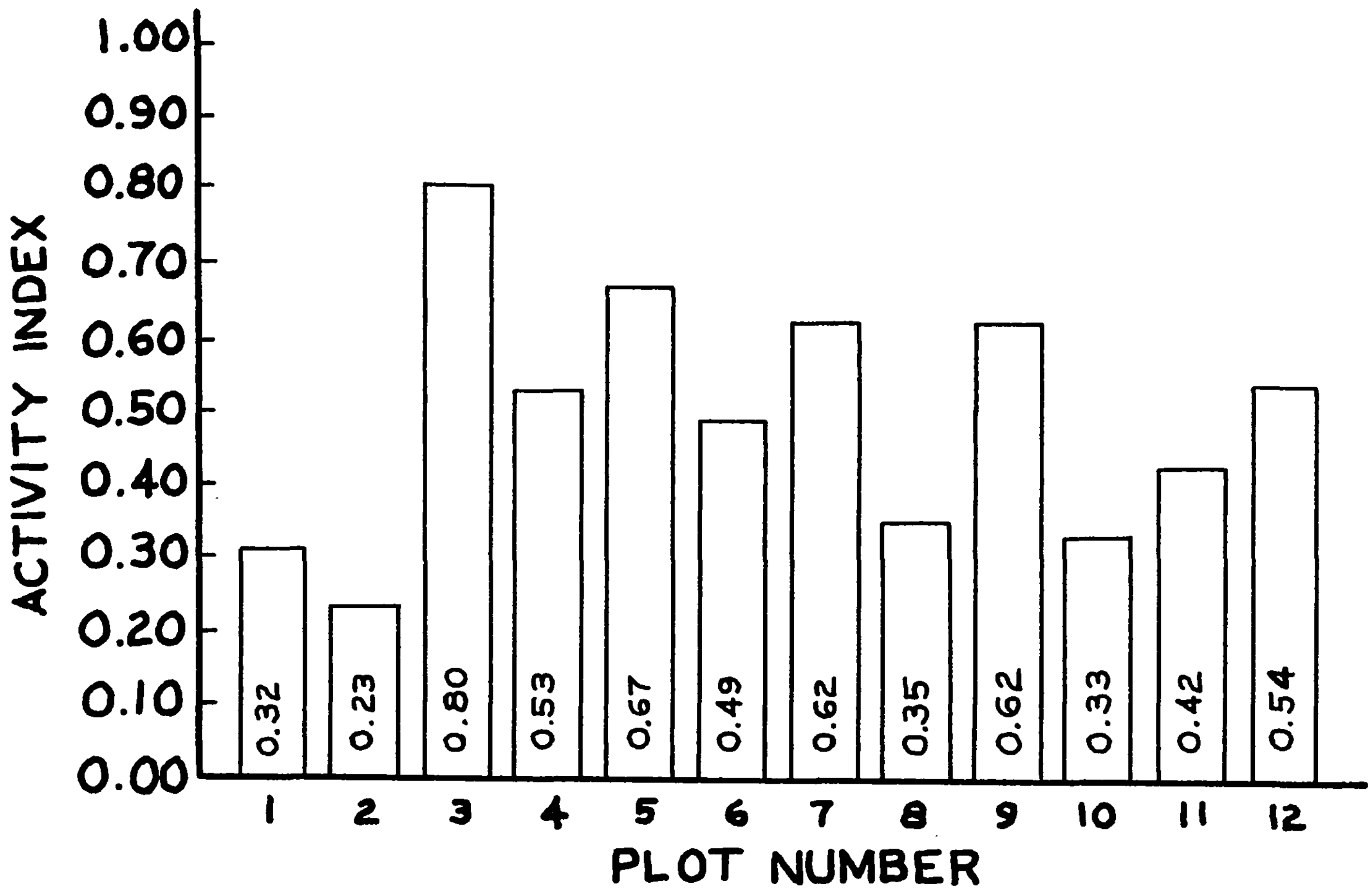

Fig. 3. Activity index for nests by study plot.

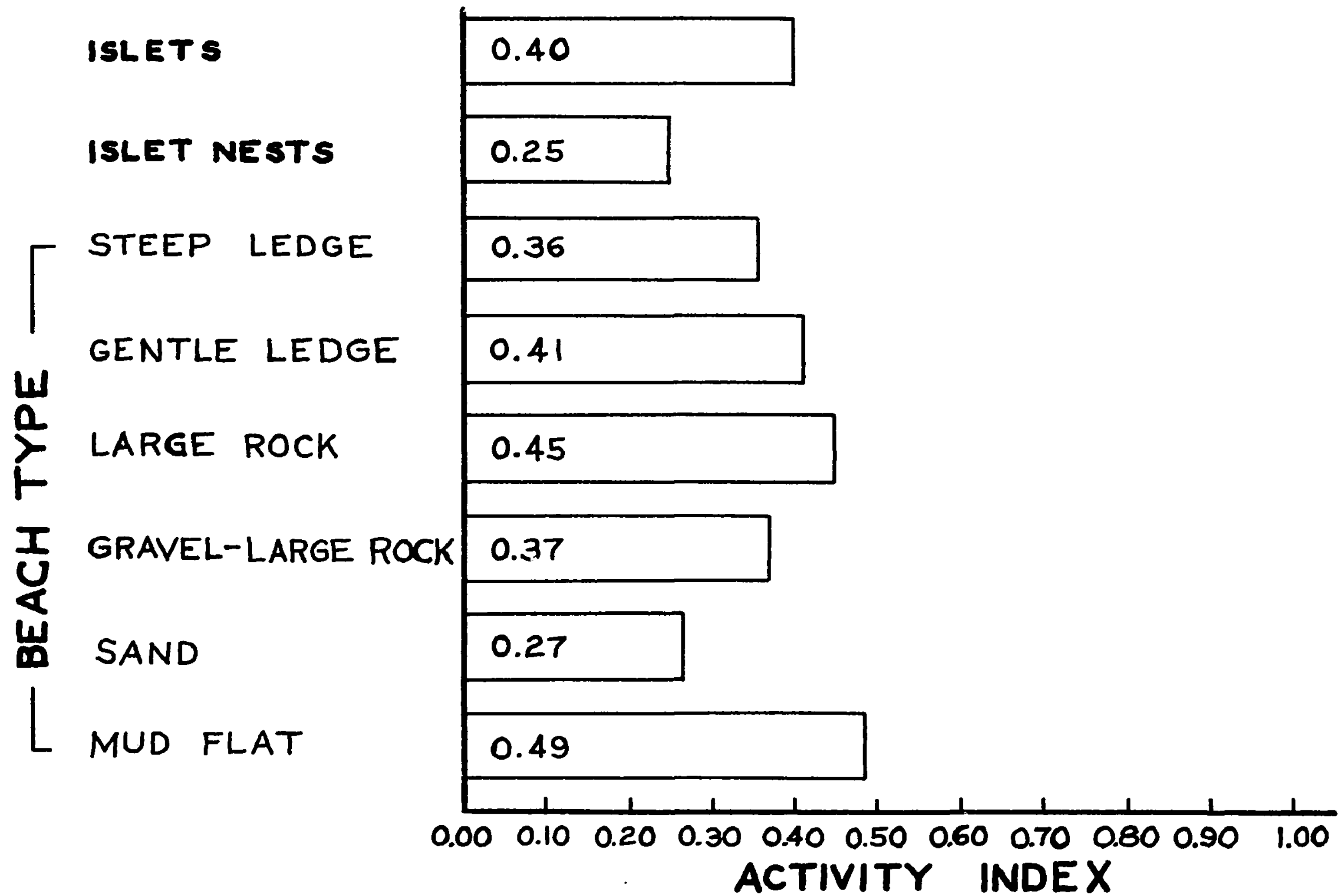

Fig. 4. Activity index for islets, islet nests, and nests by beach type.

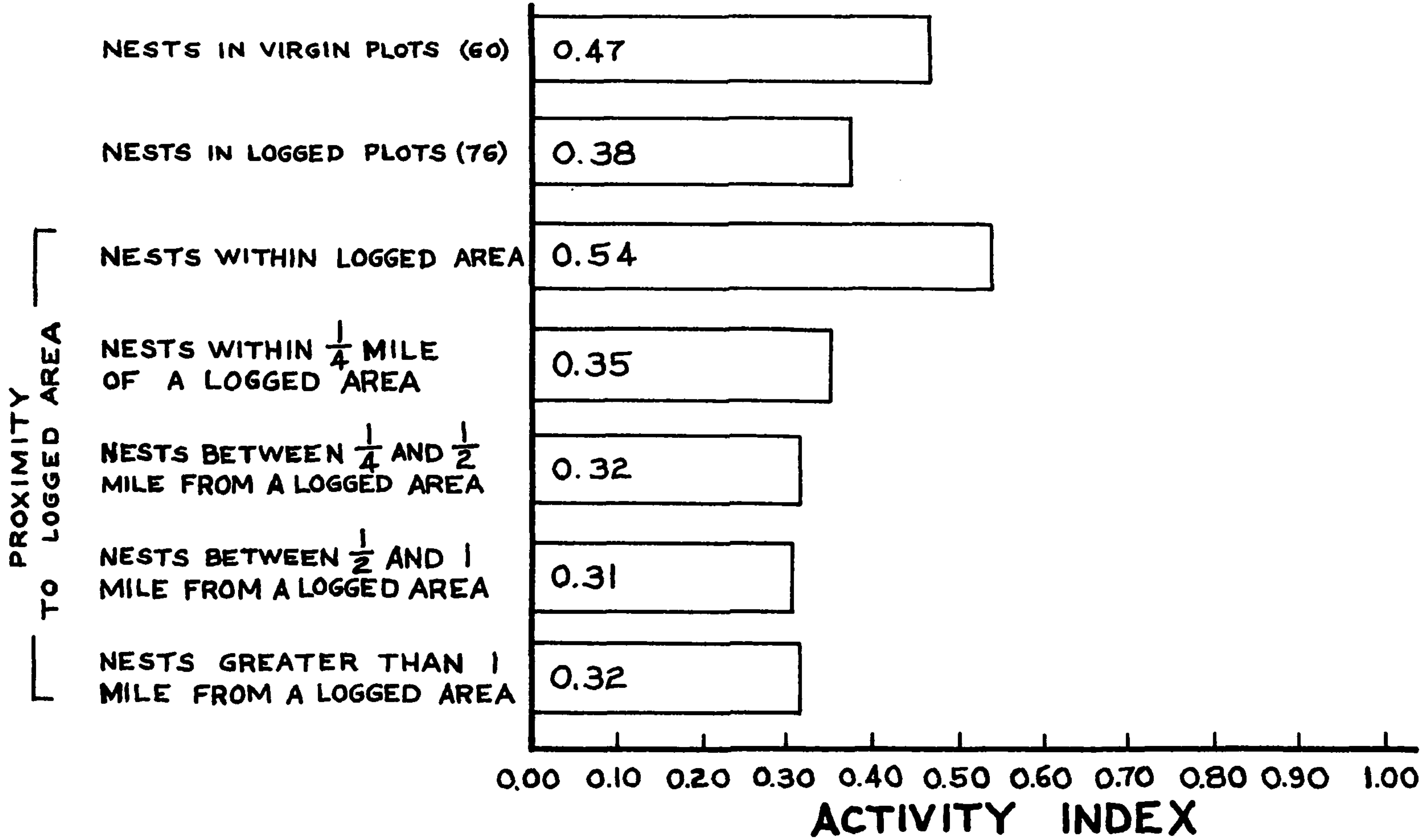

Fig. 5. Activity index for nests in virgin plots, logged plots, and by proximity to logged areas.

of the nests available in this habitat type were utilized.

Figure 4 also includes the activity index calculated for 26 islet nests and 19 islets. The index 0.25 shows that only 25 per cent of the nests on islets were utilized. This does not represent the importance of islets as a nesting habitat. On 6 of 19 islets there were two or three nests; only one of these could be active in a season because the territory of one nesting pair encompassed the other nests found on the islet. The activity index based on the 19 islets is 0.40 which indicates that 40 per cent of the islets were utilized as nesting territories during the study.

Distance between Nests

Straight line and shoreline distances between nests were measured from Forest Service maps (scale: 2 inches = 1 mile) by use of a map measure. Appendix V presents these measurements by study plot, year, and activity status of the nests.

Distance between all nests: The averages by study plot with respect to shoreline distance between nests were extremely variable. They ranged from 1,705 yards (0.97 miles) to 4,802 yards (2.73 miles). The averages by study plot with respect to straight line distance between nests were more consistent ranging from 1,526 yards (0.87 miles) to 2,813 yards (1.60 miles). The average straight line distance between nests based on all nests was 1,939 $\pm$ 267 yards (90 per cent confidence interval), and the average shoreline distance between nests based on all nests was 2,670 $\pm$ 486 yards (90 per cent confidence interval). The above measures are obviously extremely variable (standard deviation 1,636 yards and 2,551 yards, respectively), and there is a 22 yard overlap between the upper limit of the straight line estimate and the lower limit of the shoreline estimate.

Distance between active nests: Because of the extreme variability and the smaller sample sizes found in these categories, confidence intervals were not determined for these measures. The averages by study plot for the straight line distance between adjacent active nests were more variable than those based on all nests above. They ranged from 2,640 yards (1.50 miles) to 7,128 yards (4.05 miles) in 1967; 2,178 yards (1.24 miles) to 6,952 yards (3.96 miles) in 1968; and 220 yards (0.12 miles) to 12,408 yards (7.05 miles) in 1969. The averages by study plot based on shoreline distance between adjacent active nests were so variable that nothing further can be said of them.

Territory Size: Table 11 was compiled from data in Appendix V. The average by study plot based on straight line distances between adjacent active nests (29 entries) were divided by two to yield a radius of territory size.

These ranged from 110 yards (0.06 miles) to 6,204 yards (3.53 miles). Figure 6 represents the distribution of these territory sizes, and shows that they were evenly distributed about the 1,760 to 2,640 yard territory category. The use of territory here does not imply an area actively defended from encroachment by other eagles but rather a measure of spatial distribution.

Table 11. Average Territory Size (Radius in Yards) by Year and Plot

Plot Number	1967	1968	1969
1	1,902	2,110	3,094
2		1,994	1,568
3	1,320	1,925	110
4	1,980	1,587	1,376
5	1,804	1,089	
6	1,364	3,308	3,140
7		2,097	2,926
8	3,564	3,476	3,520
9		2,101	2,830
10		2,662	6,204
11	1,408		1,408
12		2,034	1,773

Comparison of Territory Size: Using the Mann and Whitney U test as described by Siegel (1956) it was possible to compare the territory sizes found in logged plots with those found in virgin plots. Territory sizes determined in each field season were used, and three separate tests were performed. In each case the null hypothesis (there is no significant difference between

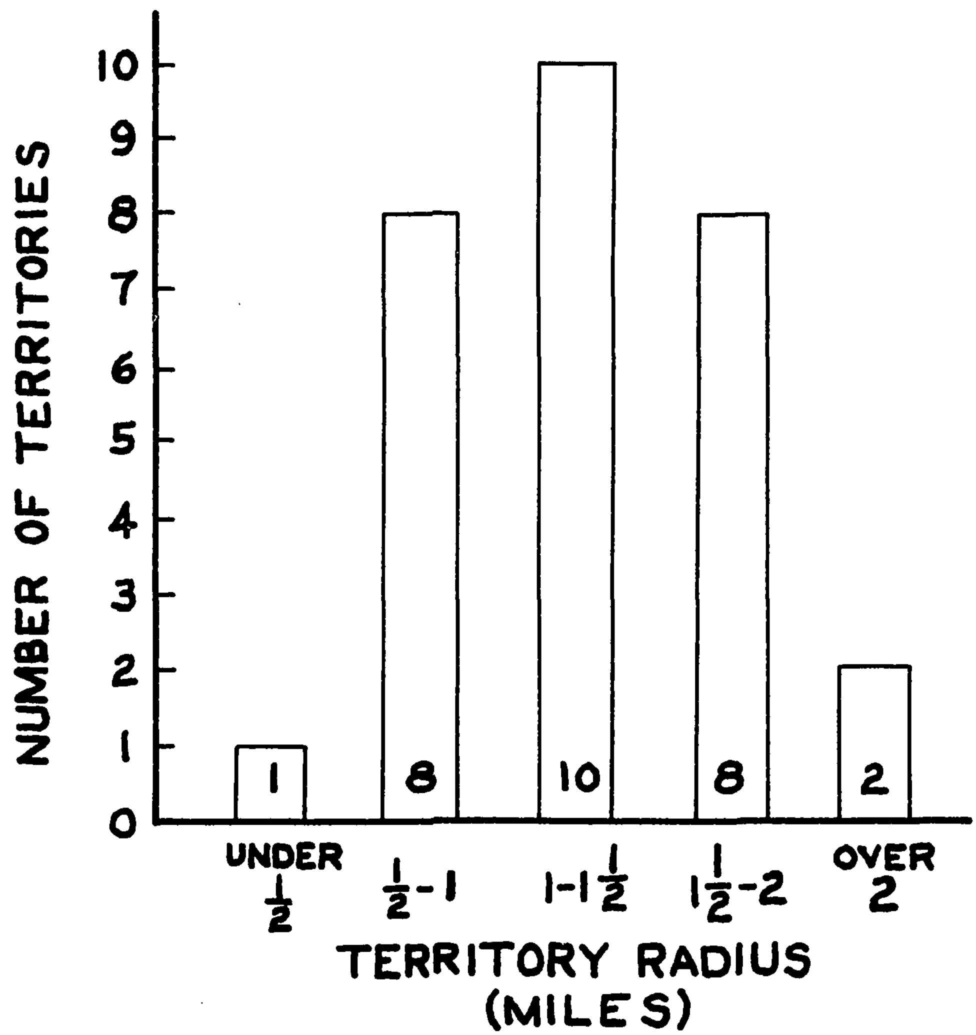

Fig. 6. Distribution of territory sizes.

territory sizes found in logged plots and those found in virgin plots) could not be rejected at the 0.05 level of significance. At this level of significance no difference in territory size was found between those in logged and those in virgin plots.

Miscellaneous Nest Site Characteristics

Nest and Nest Tree Height: Nest tree species, nest tree height, nest height, and dominance class data are presented in Appendix VI; Table 12 partially summarizes this Appendix. The average height of 128 nest trees

Table 12. Average Nest Tree Height, Nest Height, and Dominance Class - All Nests Included

Average Nest Tree Height:	118 feet ± 5	
Range:	58 - 174 feet	
Average Nest Height:	97 feet ± 4	
Range:	30 - 154 feet	
Per cent of Tree Above Nest:	18 per cent	
Range:	0 - 48 per cent	
Dominance Class:	No. of Trees	Per cent
Dominant	58	45.3
Codominant	52	40.7
Intermediate	18	14.0
Surpressed	0	0.0

was 118 ± 5 feet (90 per cent confidence interval) and the overall average nest height was 97 ± 4 feet (90 per cent confidence interval). Nests were generally in the upper one-fifth of the trees, but nest placement ranged from near the center to the very top of the nest tree. Eighty-six per cent of the nests were in either a dominant or codominant tree, and no nests were found in suppressed trees.

Nest and Nest Tree Height by Tree Species: Table 13 summarizes data from Appendix VI concerning nest and nest tree height by species. This table shows that Sitka spruce were generally taller than western hemlock, and that nests in Sitka spruce were proportionately higher than those found in western hemlock. Nest placement on the trunk was not greatly different between the two species, but nests in western hemlock tended to be located higher (in the upper 15 per cent of the trunk) than nests in Sitka spruce (in the upper 19 per cent of the trunk). The values for cedar and dead trunk classifications are of little value because of the small samples and the combination of tree species within these categories. Nests in dead trunk classification were generally lower than those found in live trees.

Species Composition of Nest Trees: Table 13 shows the species composition of the nest trees. There were 99 Sitka spruce (72.8 per cent), 18 western hemlock (13.2 per cent), nine dead trunks (6.6 per cent), eight unknown (5.9 per cent), and two cedar (1.5 per cent).

Table 13. Average Nest and Tree Height by Species

Species	Number of Sites	AVERAGES (FEET) Tree Height	Nest Height	Per cent of Trunk Above Nest
Sitka Spruce	99	123	100	19
Western Hemlock	18	101	86	15
Cedar	2	108	89	18
Dead Trunk	9	98	82	16
Unknown and Unmeasured	8			

Distance of Nest Tree From Shore: Appendix VII presents the distance between nest trees and the shore for 126 nest sites. The average distance was 108 $\pm$ 12 feet (90 per cent confidence interval) with a range from 15 to 350 feet. Nests were located near the beach frontage at all sites.

Exposed Beach by Beach Type: Appendix VIII contains the data on exposed beach at low tide by beach type. Table 14 shows these averages, their 90 per cent confidence intervals, and their ranges. There are large variations between these values within the same beach type as well as between beach types. Generally, there was more gravel - large rock beach exposed at low tide than either large rock or sand beach, but these differences are not significant.

Table 14. Average Exposed Beach by Beach Type (Yards)

Beach Type	Average Exposed Beach	Number of Estimates	Range
Steep Ledge	7± 3	19	0 - 17
Gentle Ledge	106± 23	25	27 - 240
Large Rock	61± 13	34	20 - 143
Gravel-Large Rock	82± 27	21	17 - 210
Sand	75± 98	4	33 - 167
Mud Flat	1,041±471	21	108 - 3,168

Edge punch card analysis

Edge punch cards were used to sort nests by two or more variables in an effort to observe the affects of these interacting factors. The results of this analysis are presented in Appendix IX, and show that by the second level sorting the number of nests within each category was too small to allow further breakdowns. Nests were first divided into three activity groups (those inactive during the majority of the study, those active during the majority of the study, and those for which a trend could not be established). Within these three groups the nests were sorted by beach type, tree species, distance from nest to shore, islet nests, amount of exposed beach at low tide, and whether nests were found in logged or virgin plots. The nests found in logged plots were further grouped by their proximity to a logged area. No trends were evident from this analysis, and only two factors could be related at one time due to the small number of nests in the sample and the relatively even distribution of these nests among the various factors considered. Chi-square analysis was used to determine whether the distributions of number of nests per beach type were different for the three activity groups; the results indicate no difference in the distributions ($\alpha > 0.05$).

DISCUSSION AND CONCLUSION

Location of Nests

Optimum Period: The optimum time for locating eagle nests from the air is during the period of incubation and shortly after hatching when brooding by adult birds is intensive. Nest observation is made easier because of the contrast of white head and tail feathers of the adult eagles against the dark green foliage around nest sites. In southeastern Alaska, the best period for aerial surveys is during the last week of April and the month of May. In this study, however, all flights were made during June and July, and, as a result, it is possible that some active nests were not located. Nests that were active early in the season could have been abandoned prior to the first flights. Also, early nesting birds would have been in latter stages of rearing of the young during which adult eagles visit the nest only occasionally to deliver food. In either case the chance of observing a well concealed nest would have been poor.

Aerial Nest Location: During the study a helicopter, a Piper super cruiser, and a Cessna 180 (all equipped with floats) were used to locate nests. Because of the maneuverability of the helicopter, it is the ideal aircraft for this work, but the high cost per hour and the limited fuel capacity (restricting operating range) made it impractical for this study. The Piper super cruiser was the best of the fixed wing aircraft for aerial surveys because of its slower air speed and greater maneuverability compared with the Cessna. Another factor in favor of the Piper super cruiser is its tandum seating which affords the pilot and observer the same view of the terrain.

A factor of considerable importance in locating nests is the ability and interest of the pilot. Although constantly occupied with controlling the aircraft, especially at low altitude and near stall speeds, an interested pilot often spots nests which may be missed by the observer.

Observation flights were made at as low an altitude and ground speed as was considered safe. Two or three passes along a section of beach were usually sufficient to locate nests, but occasionally as many as five or six passes were required to observe a known nest well concealed in the foliage. A pass above and behind the beach fringe (where possible) was often beneficial for location of nests. This frequently silhouetted the nests against the lighter background of water. Care in plotting the location of a nest is important to facilitate relocation from the water.

Location of Known Nests from Boat: Maps (scale 2 inches equals 1 mile) with nest locations marked from the aerial survey were used as guides for the boat and ground survey. Nests obvious from the air were often nearly impossible to observe from the ground or adjacent water. Location of known nests from a boat is facilitated by the presence of an observer to aid the boat handler. One to two passes by a known nest site were generally sufficient to locate the nest tree, but occasionally it took much longer. Mistakes in recording the location of nests in the aerial survey or misreading the terrain were causes of difficulty in locating nests from the water or ground.

Nest Density: Robards and King (1966) reported nest density of 0.53, 0.53, and 0.4 active nests per beach mile at Admiralty Island, Douglas Island-Auk Bay, and the Chilkat River, respectively. Broley (1957) reports data from 1946 indicating a nesting density of 0.56 active nests per beach mile between Englewood and St. Petersburg, Florida (this was prior to the marked decrease in the breeding success of the population and the intense land development in this region). Troyer and Hensel (1965) report finding 158 active nests and estimate that 190 nests were active during 1963 on Kodiak Island National Wildlife Refuge. There are roughly 725 miles of beach on Kodiak Island thus yielding nest densities of 0.22 and 0.26 active nests per beach mile.

Nest density in the Petersburg area was much lower than in the Admiralty Island, and Douglas Island sections of Robards' and King's study, but compares closely to densities estimated for Kodiak Island in 1963. The density of nests in the 12 study plots ranged from 0.09 to 0.46 active nests per beach mile. The over-all nest density was 0.20, 0.23, and 0.20 active nests per beach mile in 1967, 1968, and 1969, respectively. These values are much lower than Robards' and King's over-all density of 0.49 active nests per beach mile. Only plot twelve with 0.46 active nests per beach mile approximates the densities found in Admiralty Island and the Douglas Island-Auk Bay areas. This plot was the least altered and most remote of all plots in the Petersburg area.

Territory size

The term territory as used in this study refers to the radius associated with an active nest, and does not imply an area actively defended against encroachment by other eagles. Territory size was considered to equal half the straight line distance between adjacent active nests. Hensel and Troyer (1964) report territory size as the area encompassed by the perches associated with active nests at Karluk Lake, Kodiak Island. Calculations of radii for circles with areas identical to the territory sizes reported for Karluk Lake nests are far too small to represent spatial distribution. Since these nests were on a lake as opposed to coastal waters and the method of reporting territories was by area, the results are not comparable to this study or to the literature. Robards and King (1966) state that 700 yards appeared to be the minimum distance between active nests, and that this could indicate territory size. Broley (1947) states that the territory radius found in Florida approximates 0.5 mile.

Territory sizes found in this study are much larger than those previously reported in the literature. The territories for all 3 years were distributed evenly about a radius of 2200 yards (1.25 miles) as shown by Fig. 6. If this is considered the average territory size for eagles in the Petersburg area, it is over twice that found by Broley and three times that reported by Robards and King.

The greater spatial distribution of active nests in the Petersburg area (as opposed to Admiralty Island, and Douglas Island-Auk Bay) appeared to be due to three factors. The first is a smaller resident breeding population of bald eagles in the Petersburg area. The second is logging of beach frontage in the Petersburg region resulting in fewer available nest sites along an area with logged beach. Third is a larger human population in the Petersburg region and increased eagle-human interaction.

Production

Broley (1947) reported average production from 36 nests in 1946 as 1.6 young per nest. Mathisen (1970a) presents the results of an eight year study showing production ranging from 1.2 to 1.8 young per nest. Hensel and Troyer (1964) found 0.9, 0.6, and 1.4 young per nest in a three year study. Troyer and Hensel (1965) report 1.6 young per nest and Robards and King (1966) found 1.42 fledglings per nest. Grewe (1966) reported production of 1.82, 1.61, and 1.21 young per nest.

Production data from the Petersburg study area compare favorably with the literature. There was an average of 1.5, 1.65, and 1.53 young per nest in 1967, 1968, and 1969, respectively. These values do not represent fledglings, and were based on single counts conducted early in the nesting season. Active nests in the study area appeared to produce eaglets at a rate comparable to that found in other areas of the eagle's range.

Nest Desertion, Renesting, and Relocation of Nests

Instances of renesting after loss of eggs early in the season have been reported in the literature (Herrick, 1924b; Hoxie, 1910; Willard, 1906) and the desertion of a nest after loss of eggs or young is well documented (Broley 1947). Indications point to the occurrence of these two situations during the course of this study.

During the second field season aerial surveys over the study plots were conducted in May by the Fish and Wildlife Service, and the results were recorded on Forest Service maps. Nest site 12 was recorded as active at this time and nest 14 was inactive. During subsequent boat work in June and July, it was noted that nest site 14 was active with two eaglets and nest 12 was inactive. It is surmised that this pair lost their original eggs, deserted the nest and renested successfully at an adjacent site.

After the loss of a favored nest site, eagles will tend to relocate within their territory if suitable nest trees are available (Broley 1947). This was the case in numerous instances after the winter storm of 1968-1969 and the loss of 23 nests or nest trees. Looking at Maps 2, 5, and 6 in Appendix II, it is noted that many of the new nests observed in 1969 are located near a nest lost during the previous winter. These new nests were possibly built by displaced pairs attached to the particular territories.

Nest Location

Nest densities showed little variation among beach types with the exception of mud flat beach which supported fewer nests than expected if nests are distributed according to the abundance of a particular beach type. This appears to be the case in the other five beach classifications.

Nests were found along shores of large straits (Sumner Strait, Keku Strait, and Frederick Sound) and a large tidal bay (Duncan Canal). These sites are favorable nesting areas according to Robards and King (1966). They report finding few nests in small bays and inlets whose shores remain ice bound well into the breeding season. Not enough of the latter habitat was present in the current study to comment on this point.

King, et. al. (1972) state that clusters of islets or broken shoreline tended to support greater nest densities than areas without islets and a uniform shoreline. In this study, plot twelve was representative of the latter habitat, but supported the greatest active nest density of any plot (0.46 active nests per beach mile). Plot one, representative of habitat with broken shoreline with islets, supported approximately half the active nest density found in plot twelve. If nest density based on all nests located during the study is used, both plots are similar (0.87 and 0.81 nests per beach mile for plot one and twelve, respectively).

In a forest which is predominantly western hemlock (roughly 70 per cent), there appears to be a definite preference for Sitka spruce nest trees. Over 70 per cent of the nest trees were Sitka spruce, 13 per cent were western hemlock, and slightly over 13 per cent were in the other three categories (dead trunk, cedar, and unknown). Estimates made during the study indicate that within the first 0.1 mile from shore the percentage of Sitka spruce to western hemlock is approximately equal. Assuming that Sitka spruce and western hemlock exist in equal proportions near the beach, an apparent preference for Sitka spruce exists. This is possibly due to the greater height afforded by Sitka spruce and a strong, stable limb structure compared to western hemlock.

Another explanation for this apparent selection of Sitka spruce is evident from an analysis of the 25 nest trees lost during both winters of the study. Of these nest trees destroyed, 33 per cent of the known western hemlock nest trees were lost; 21 per cent of the dead trunk, cedar, and unknown nest trees were lost; and only 15 per cent of the known Sitka spruce nest trees were lost. This would indicate a definite natural selection for Sitka spruce nest trees as opposed to the other species. Over a long period of time this selection would leave a larger percentage of Sitka spruce nest trees in the population.

Human disturbance may have varied impact on different eagles, but for the population as a whole its effects are considered detrimental. Nest sites which are constantly visited or otherwise disturbed have a greater chance for failure than those that are relatively isolated. No nest located within the twelve plots was known to be deserted because of human disturbance, but limited use of certain areas by eagles was associated with human disturbance. This is apparent particularly along the shore of Mitkof and Kupreanof Island near Petersburg and along the shore of Woewodski Island and Kupreanof Island in Duncan Canal south of the mouth of Beecher's Pass. The waters off of these beaches are heavily utilized by commercial and pleasure craft operators; this increases the opportunity for interaction and conflict between eagles and man.

Shooting of eagles was not observed during the study. Reports of shootings and abandoned eaglets were received, but these did not involve pairs in the study plots. These incidents occurred near the town of Petersburg itself. Only one instance of a possible shooting was observed. The eaglet in its six or seventh week was found below nest number 69 (see Fig. 7). It was so poorly preserved that the cause of death could not be determined. The eaglet either fell from the nest and was killed by predators, or he was shot and later eaten as carrion.

Logging

Logging affects local eagle populations during the period of logging activity as well as after the harvest has been completed. Plot one illustrates the importance

Fig. 7. Six to seven week old eaglet found at base of nest site 69, plot four. Cause of death was undetermined.

of the presence of islets in sustaining a breeding population of eagles where the main shore has been harvested by extensive clear-cutting. There were 21 out of 46 nests in plot one located on these islets. No nests were found within the borders of logged areas in the western section of plot one.

Only one other small logging site was active during the study; this was located in the central section of plot two in the summer of 1969. Just one nest (number 7) of the four located in plot two was active in 1969, and it was located over 1 mile from the border of the active logging site. This was a decrease from two active nests within the plot in 1968.

Active logging operations result in fewer available nests sites within affected areas, and there is an occasional loss of nests due to the operation. Active logging appears to force eagles out of the immediate area during the breeding season, but in the years following the harvest, eagles move back into logged sites if suitable nest trees are left in the beach fringe. These sites are used frequently with good success as indicated by the activity index for this group. There is one serious problem with these beach fringe nests. They are subject to wind throw and storm damage because the protection resulting from surrounding timber has been removed, and the shallow rooted trees are easily wind thrown. The life expectancy of these nests may be only equal to the interval between severe winter storms (similar to the one of 1968-1969 which destroyed 23 of 115 known nests).

Climatic Factors and Eagle Nesting

Delays in melting of winter ice along the shores of the study plots did not have an adverse affect on breeding success of pairs. It was noted that in 1969 there was a greater frequency of eggs and downy young as opposed to older eaglets during the early aerial surveys than there was in 1968. This could possibly have been a result of the extremely cold winter and spring of 1969 or a delay caused by nest damage from winter storms.

Nest Loss: Nest loss during the study period was directly related to effects of storms. The majority of the lost nests resulted from storms in the winter of 1968-1969; 23 nests were lost during this winter. Many of these nests were found in beach fringe timber left after a timber harvest. In plot five, which consists primarily of this habitat type, four of the five known nests were lost.

Population Movements: Shifts in population density between plots were noted between 1968 and 1969. The severe winter storms of 1968-1969 are suspected to be the cause for this movement. The number of breeding pairs in the eight plots studied in 1967 and 1968 remained fairly constant, but between 1968 and 1969 some large changes occurred. The number of breeding pairs in plot one was stable between 1967 and 1968 (14 and 15 pairs, respectively) but dropped to nine breeding pairs in 1969. The same trend was noted in plot five where there were three and four breeding pairs in 1967 and 1968, respectively. This number dropped to only one breeding pair in 1969. Increases in the number of pairs found in plots four and eight probably result from displacement of some pairs from plot one and five.

<u>Summary</u>

<u>Surveys</u>: Aerial surveys are more reliable during late April and May when adult eagles are actively incubating eggs or brooding young.

<u>Production</u>: Eaglet production per active nest within the study area compared favorably to production reported from other eagle populations.

<u>Nest Density</u>: Nesting density in the study area was lower than that found in the Admiralty Island region of southeastern Alaska. Only plot twelve, which is remote and in virgin timber, sustained a nesting density comparable with the Admiralty Island population. Beach types associated with this high nest density were gentle-sloped ledge and large-rock beach.

Nest Sites: Nest trees were always located near the shore, and were seldom over 100 yards from the beach. Nests were always situated in a position affording observation of the beach and water.

Nest Tree Species: A preference for Sitka spruce was evident in all plots; over 70 per cent of the nests were in Sitka spruce.

Beach Type: No apparent selection for a particular beach type was found. Nest sites were distributed proportionately among beach types with the exception of one type. Eagles did not utilize nest sites available with mud flat beaches as frequently as expected from the extent of this beach classification found in the study plots.

Nest Activity Index: The overall nest activity index was lower for nests in logged plots than for nests in virgin stands. The activity index was, however, highest for nests located in beach fringe timber within logged areas. This is due to lack of alternate nest sites in these areas which results in consistent use of available nests.

Islet Nest Sites: Where small islets are present, they provide nesting sites for use if the main shore habitat is disturbed. These sites were extremely important to the eagle population of plot one.

Logging: Although certain individual eagles tolerate human disturbance associated with logging, evidence indicates that this source of disturbance may be critical during early stages of nesting (Mathisen, 1968). Extensive cuts involving miles of shoreline (Point Barre region of plot one) remove potential nest sites and occasionally nests over extensive areas. Unless a substantial beach fringe is left in these areas or there are numerous small islets offshore, the eagle population will be forced from the area for lack of suitable nest sites.

Nest Loss: Nest trees left in beach fringe timber are extremely vulnerable to wind throw or damage. Because of this, even though there is an apparent consistent use of these areas (Activity Index), the value of beach fringe nest sites is questionable. Nests built in suitable trees have a short life span because of reduced protection resulting from decreased amounts of surrounding timber. Suitable nest trees in beach fringe are generally limited.

Nest loss due to factors other than storm damage were not observed during the two winters of the study. One nest site (number 9) was observed to be leaning sharply during the summer of 1968; this was caused by a wash-out around supporting roots (see Fig. 8).

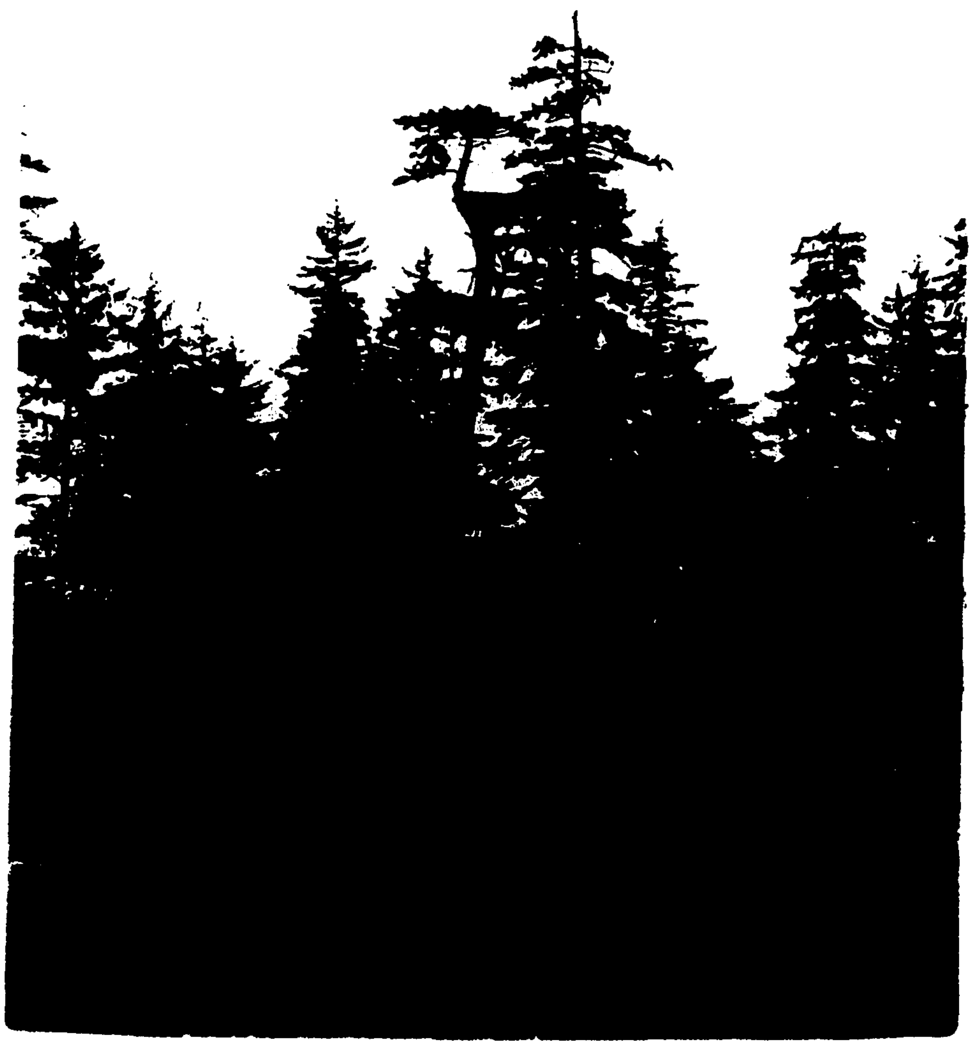

Fig. 8. Nest nine, plot two, was leaning sharply due to the wash-out of the tree's root system.

Recommendations

1. Surveys of all proposed timber sales should be made to assertain their value as nesting habitat for eagles.
2. Nests present within proposed timber sales should be protected by buffer zones (recommended size: 660 ft. radius or 10 chains). Regulations governing buffer zones around nest trees, and restriction of harvesting activity from areas of active nests during April and May should be enforced.
3. Smaller timber sales should be promoted to reduce the number of extensive beach cuttings and the clear cutting of entire islands.
4. Educational programs for fishermen, loggers, and others to increase their awareness of the eagles economic, biological, and esthetic value should be continued and expanded. Also the promotion and explanation of ecological principles with respect to timber harvest, economics, and esthetic value should be initiated in schools and through the news media.

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APPENDIX I

DESCRIPTIONS OF STUDY PLOTS

Plot One

The descriptive data for plot one is presented in Table I 15. Plot one is the largest of the twelve plots and is located along the southern shore of Kupreanof Island (Map 2, Appendix II). The plot is 53.0 miles long and extends from Mitchell Point on the eastern boundary to approximately 1 mile north of Skiff Island in Keku Strait. Two large bays, Totem and Douglas, and many nameless inlets are included along this southern shore of Kupreanof Island. The many small islets within 2 miles of the main shore are included in the plot.

Table I 15. Descriptive Data - Plot One

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	48,840	27.75	52.4
Virgin Beach	44,440	25.25	47.6
Total Length	93,280	53.00	100.0
Beach Type:			
Steep Ledge	3,520	2.00	4.0
Gentle Ledge	12,320	7.00	13.0
Large Rock	28,160	16.00	30.0
Gravel-Large Rock	35,200	20.00	38.0
Sand	0	0.00	0.0
Mud Flat	14,080	8.00	15.0
Total Length	92,280	53.00	100.0

The terrain rises gradually from the beach over most of the plot, and extensive muskeg has developed behind the beach timber. Only between Point Barre and Totem Point in the western section does the land rise above the 200 foot elevation within 1 mile of shore. Over one-half of the entire beach frontage (27.8 miles, 52 per cent) has been logged since 1930 with the greatest effort occurring after 1957.

A great percentage of the cut over area is located in the western section of the plot, and has resulted in scattered timber in a rough beach fringe. Smaller logged areas in Totem Bay and Douglas Bay account for the remainder of the logging activity.

Keku Strait borders the plot on the west, and Sumner Strait forms the southern shore. These large bodies of water are used by commercial fishing fleets, and by logging companies for transporting log rafts. There were no inhabitants along the shores of plot one except at an active logging camp north of Point Barre in 1967 and 1968. Most water activity occurred far offshore with only occasional pleasure boaters, fisherman, and hunters entering the bays or landing on the beaches of plot one.

Plot Two

Table I 16 presents the descriptive data for plot two. This plot is located along the northwestern shore of

Duncan Canal, Kupreanof Island, (Map 3, Appendix II). Its southern boundary is due west of Cloverleaf Island, and the northern border is three-quarters of a mile south of Indian Point.

A small logging operation in 1929 was the first cutting within the central portion of the plot; this original site was enlarged in 1961. In 1951 another small plot was cut 1 mile north of first site, and in 1969 an active logging operation was extending this site northward (see Fig. 1 of the text).

Table I 16. Descriptive Data - Plot Two

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	3,960	2.25	39.1
Virgin Beach	6,160	3.50	60.9
Total Length	10,120	5.75	100.0
Beach Type:			
Steep Ledge	0	0.00	0.0
Gentle Ledge	0	0.00	0.0
Large Rock	0	0.00	0.0
Gravel-Large Rock	1,408	0.80	14.0
Sand	4,752	2.70	47.0
Mud Flat	3,960	2.25	39.0
Total Length	10,120	5.75	100.0

The elevation of the central section of the plot rises quickly to over 200 feet. In the northern and southern portions the terrain is lower and more even.

Human disturbance at this plot was considered highly probable because of the current logging, the FAA station at Indian Point, and the active mine on Big Castle Island. Two Forest Service recreation cabins are located in the vicinity and provided shelter for occasional visitors.

Plot Three

Plot three is located on the eastern shore of Mitkof Island and faces Frederick Sound (Map 4, Appendix II). The plot extends 9.8 miles south of Frederick Point to the blunt point WNW of Coney Island. The terrain along the 4 miles south of Frederick Point rises steeply in the first mile from shore to an elevation of 1000 feet except in the stream valley. From this point south the elevation rises to only 200 feet in the first mile from shore. Table I 17 contains descriptive data for plot three.

Table I 17. Descriptive Data - Plot Three

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	8,360	4.75	48.8
Virgin Beach	8,800	5.00	51.2
Total Length	17,160	9.75	100.0
Beach Type:			
Steep Ledge	1,320	0.75	7.7
Gentle Ledge	0	0.00	0.0
Large Rock	3,300	1.88	19.3
Gravel-Large Rock	5,500	3.12	32.0

Table I 17. Contd.

	Length Yards	Miles	Per cent
Sand	0	0.00	0.0
Mud Flat	7,040	4.00	41.0
Total Length	17,160	9.75	100.0

Approximately one-half (48.8 per cent) of the beach frontage has been logged since 1955. In one area a logging operation was completed in 1937, but no obvious remains were visible at the time of this study.

Only a slight degree of human disturbance along the shores of plot three is probable. Parties of hunters and pleasure boaters from Petersburg or Wrangell may on occasion stop along the beaches of plot three.

Plot Four

Plot four is located on the western shore of Duncan Canal on Kupreanof Island; plot seven breaks this plot into a northern and southern section, (Map 5, Appendix II).

There are 16.3 miles of beach in plot four containing numerous small logged areas dating back to 1934. Most of the logging activity occurred between 1960 and 1966. Although there are five separate logged areas, only 6.3 miles (39 per cent) of beach have been cut. The terrain rises above the 200 foot elevation within 1 mile of the beach throughout most of the plot, and there are steep rock bluffs in the northern section of the plot.

Table I 18. Descriptive Data - Plot Four

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	11,088	6.30	38.9
Virgin Beach	17,512	9.95	61.1
Total Length	28,600	16.25	100.0
Beach Type:			
Steep Ledge	1,056	0.55	3.4
Gentle Ledge	2,464	1.40	8.6
Large Rock	3,080	1.70	10.4
Gravel-Large Rock	4,224	2.40	14.7
Sand	0	0.00	0.0
Mud Flat	17,776	10.20	62.9
Total Length	28,600	16.25	100.0

There were no active logging operations in the plot during the study, but occasional human disturbance was likely. The plot is directly opposite the entrace of Beecher's Pass (a passage between Wrangell Narrows and Duncan Canal) and forms the western shore of the Canal. Because of this location there is frequent opportunity for contact by fisherman, hunters, and pleasure boaters. Forest Service recreation cabins at the mouth of Beecher's Pass and south of Big Castle Island also provide opportunities for human disturbance.

During the winter of 1968-1969 severe gale winds blew down sections of timber in the southern portion of the plot (see Fig. 2 of the text).

Plot Five

Plot five consists of three islands comprising the Level Islands in Sumner Strait (Map 5, Appendix II). Table I 19 presents the descriptive data for the plot. The islands have been heavily logged; the perimeter of the largest island and the entire area of the nest largest island were cut between 1947 and 1966. A rough fringe of beach timber was left around the largest island, and the interior is largely muskeg. People associated with a radio installation on the larger island were a source of human disturbance. Aside from this, the islands are quite remote and very little disturbance is likely. The winter storms of 1968-1969 had disasterous affects on the islands nesting population. During these storms four of the five known nests were destroyed.

Table I 19. Descriptive Data - Plot Five

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	14,168	8.05	93.1
Virgin Beach	1,056	0.60	6.9
Total Length	15,224	8.65	100.0

Table I 19. Contd.

	Length Yards	Miles	Per cent
Beach Type:			
Steep Ledge	0	0.00	0.0
Gentle Ledge	8,624	4.90	56.7
Large Rock	6,600	3.75	43.3
Gravel - Large Rock	0	0.00	0.0
Sand	0	0.00	0.0
Mud Flat	0	0.00	0.0
Total Length	15,224	8.65	100.0

Plot Six

Plot six is located along the eastern shore of Duncan Canal, Kupreanof Island (Map 3, Appendix II). The plot extends 13.5 miles northward from Grief Island to Mitchell Slough. The terrain rises steeply to over 1000 feet within the first mile from shore in the southern half of the plot. In the northern region the slope levels off, and the elevation remains at 200 feet above sea level or below.

The descriptive data in Table I 20 shows that only 3.3 miles (24 per cent) of the beach have been logged. Four logged areas have been harvested between 1961 and 1964, and one small area was completed in 1939.

Table I 20. Descriptive Data - Plot Six

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	5,725	3.25	24.2
Virgin Beach	18,045	10.25	75.8
Total Length	23,770	13.50	100.0
Beach Type:			
Steep Ledge	0	0.00	0.0
Gentle Ledge	0	0.00	0.0
Large Rock	616	0.35	2.6
Gravel-Large Rock	12,056	6.85	50.7
Sand	704	0.40	3.0
Mud Flat	10,394	5.90	43.7
Total Length	23,770	13.50	100.0

No signs of human disturbance were observed during the course of the study except at the northern border of the plot. Sand and gravel were removed from this area for construction of a road from the beach to a radio tower two miles away. There were undoubtedly occasional visitors to the shores of plot six, but the extent of the disturbance was probably minimal.

Plot Seven

Plot seven is located on the western shore of Duncan Canal, Kupreanof Island; this plot is divided into three sections selected to include only mud flat beach (Map 3, Appendix II). These sections include the large flats between Tower Arm and Indian Point, those at the mouth of Castle River, and those in Little Duncan Bay. Table I 21 presents descriptive data for this plot. One small logged area (0.4 miles of beach) cut in 1967 was the only logging activity within the plot. This accounted for only 1 per cent of the 34.0 miles of beach, and was located in Little Duncan Bay. The other two sections of the plot were virgin stands.

Table I 21. Descriptive Data - Plot Seven

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	660	0.38	1.1
Virgin Beach	59,180	33.62	98.9
Total Length	59,840	34.00	100.0
Beach Type:			
Steep Ledge	0	0.00	0.0
Gentle Ledge	0	0.00	0.0
Large Rock	0	0.00	0.0
Gravel-Large Rock	0	0.00	0.0
Sand	0	0.00	0.0
Mud Flat	59,840	34.00	100.0
Total Length	59,840	34.00	100.0

Very little human activity was observed in the plot apparently as a result of the difficult boating waters adjacent to it. Only occasional hunters and fisherman would reach the shores of plot seven.

The terrain surrounding the sections of plot seven is generally low, and does not rise above the 200 foot elevation within 1 mile of shore. Only along the southern shore of Little Duncan Bay does the terrain rise steeply from shore.

Plot Eight

Plot eight is 12.2 miles long, and is located on the southern shore of Mitkof Island (Map 6, Appendix II). The plot extends from Point Alexander east to the mouth of Blind Slough, and forms the northern shore of Sumner Strait. Table I 22 shows the descriptive data for the plot. There are no logged areas within the plot, and the terrain rises steeply from the shore over most of it's length. No buildings were located in the plot, and little human disturbance was observed. Sumner Strait is an active transportation route between Wrangell and Petersburg, but most of this activity occurs well offshore and has little direct affect on nesting eagles.

Table I 22. Descriptive Data - Plot Eight

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	0	0.00	0.0
Virgin Beach	21,472	12.20	100.0
Total Length	21,472	12.20	100.0

Table I 22. Contd.

	Length Yards	Miles	Per cent
Beach Type:			
Steep Ledge	7,216	4.10	33.6
Gentle Ledge	1,848	1.05	8.6
Large Rock	10,384	5.90	48.4
Gravel-Large Rock	2,024	1.15	9.4
Sand	0	0.00	0.0
Mud Flat	0	0.00	0.0
Total Length	21,472	12.20	100.0

Plot Nine

Plot nine is located along the eastern shore of Kupreanof Island north of Petersburg and forms a portion of the southwestern shore of Frederick Sound (Map 7, Appendix II). Table I 23 shows the descriptive data for plot nine; there are 14.5 miles of beach included within the plot, and there has been no logging activity along the shores. The terrain slopes gradually from the shore in the northern one-third of the plot; in the southern portion the land rises steeply from the beach except in the creek valleys. During the fishing season there is considerable activity along the shores of this plot; both commercial and sport fisherman worked close to shore with trolling rigs and gill nets. Cabins were located at the mouths of Five Mile Creek and Twelve Mile Creek indicating human use of these area at certain parts of the year.

Table I 23. Descriptive Data - Plot Nine

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	0	0.00	0.0
Virgin Beach	25,520	14.50	100.0
Total Length	25,520	14.50	100.0
Beach Type:			
Steep Ledge	6,336	3.60	24.8
Gentle Ledge	0	0.00	0.0
Large Rock	9,680	5.50	37.9
Gravel-Large Rock	5,544	3.15	21.8
Sand	2,376	1.35	9.3
Mud Flat	1,584	0.90	6.2
Total Length	25,520	14.50	100.0

Plot Ten

Plot ten is located on the northern shore of Zarembo Island and fronts on Sumner Strait (Map 6, Appendix II). Table I 24 shows that only 0.3 miles of beach have been logged out of 19.0 miles of beach within the plot. Plot ten extends from the western entrance of Saint John Harbor east to Craig Point. The terrain surrounding Saint John Harbor and Baht Harbor rises gradually from shore, but it does reach an elevation of 200 feet within 1 mile of the shore. Over the remaining portions of the plot the terrain is very steep, and rises to over 200 feet within a few hundred yards of the shore. No camps were present and only one small logged area from the 1940's was found.

Occasional human disturbance in the Saint John Harbor region was expected from pleasure boaters and commercial fisherman, but very little human use of the remaining portions of the plot was observed.

Table I 24. Descriptive Data - Plot Ten

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	440	0.25	1.3
Virgin Beach	33,000	18.75	98.7
Total Length	33,440	19.00	100.0
Beach Type:			
Steep Ledge	8,536	4.85	25.6
Gentle Ledge	704	0.40	2.1
Large Rock	8,360	4.75	25.0
Gravel-Large Rock	3,872	2.20	11.6
Sand	968	0.55	2.9
Mud Flat	11,000	6.25	32.8
Total Length	33,440	19.00	100.0

Plot Eleven

Plot eleven extends for 9.2 miles from the mouth of Beechers' Pass in Duncan Canal south along the western shore of Woewodski Island, through Wiskey Pass, and east along the southern shore of the island (Map 5, Appendix II). Sumner Strait and Duncan Canal border this plot. The terrain rises gradually but steadily over the entire length of plot eleven. Table I 25 presents the descriptive data for this plot. Considerable human disturbance was encountered in the northern portion of this plot, but there was no logging activity present. Inhabitants near the mouth of Wiskey Pass, pleasure boating, and fishing were the primary causes of human disturbance along the shores of this plot located within Duncan Canal. The southern shore of Woewodski Island was relatively isolated, and little human use of this portion of the plot was observed.

Table I 25. Descriptive Data - Plot Eleven

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	0	0.00	0.0
Virgin Beach	16,192	9.20	100.0
Total Length	16,192	9.20	100.0
Beach Type:			
Steep Ledge	6,424	3.65	39.6
Gentle Ledge	1,408	0.80	8.7
Large Rock	2,288	1.30	14.1
Gravel-Large Rock	0	0.00	0.0
Sand	0	0.00	0.0
Mud Flat	6,072	3.45	37.6
Total Length	16,192	9.20	100.0

Plot Twelve

Plot twelve is located on the northern shore of Kupreanof Island excluding the shores of Portage Bay (Map 8, Appendix II). Table I 26 shows that only 0.5 miles of 28.5 miles of beach within the plot have been logged;

this area was located near the mouth of Portage Bay. The terrain east of the entrance to Portage Bay rises steeply from the shore within the first one-quarter mile; in many areas there are steep cliffs next to shore. The elevation of the terrain in the western section of the plot is much lower and slopes very gradually from the beach. The land does not reach the 200 foot elevation within the first mile from shore in this region of plot twelve. Behind the beach timber is extensive muskeg development over the entire region west of Portage Bay. Because of the large percentage of gentle sloped ledge and large rock beach in plot twelve, the shore is protected from human disturbance. Boating near the shore is practically impossible in many areas. Human disturbance is of importance only around the entrance to Portage Bay where commercial fisherman and pleasure boaters frequently congregate. Only in rare instances would human disturbance be a factor in eagle production in plot twelve.

Table I 26. Descriptive Data - Plot Twelve

	Length Yards	Miles	Per cent
Shoreline:			
Logged Beach	880	0.50	1.8
Virgin Beach	49,280	28.00	98.2
Total Length	50,160	28.50	100.0

Table I 26. Contd.

	Length Yards	Miles	Per cent
Beach Type:			
Steep Ledge	0	0.00	0.0
Gentle Ledge	27,984	15.90	55.8
Large Rock	12,760	7.25	25.4
Gravel-Large	9,416	5.35	18.8
Sand	0	0.00	0.0
Mud Flat	0	0.00	0.0
Total Length	50,160	28.50	100.0

APPENDIX II

MAPS

LEGEND: MAPS 2 thru 8

Tree Species

▲ Sitka spruce

● western hemlock

■ dead trunk

◪ cedar

⊙ species unknown

Nest Status (1967, 1968, 1969)

+ active

1 or 2 number of eaglets

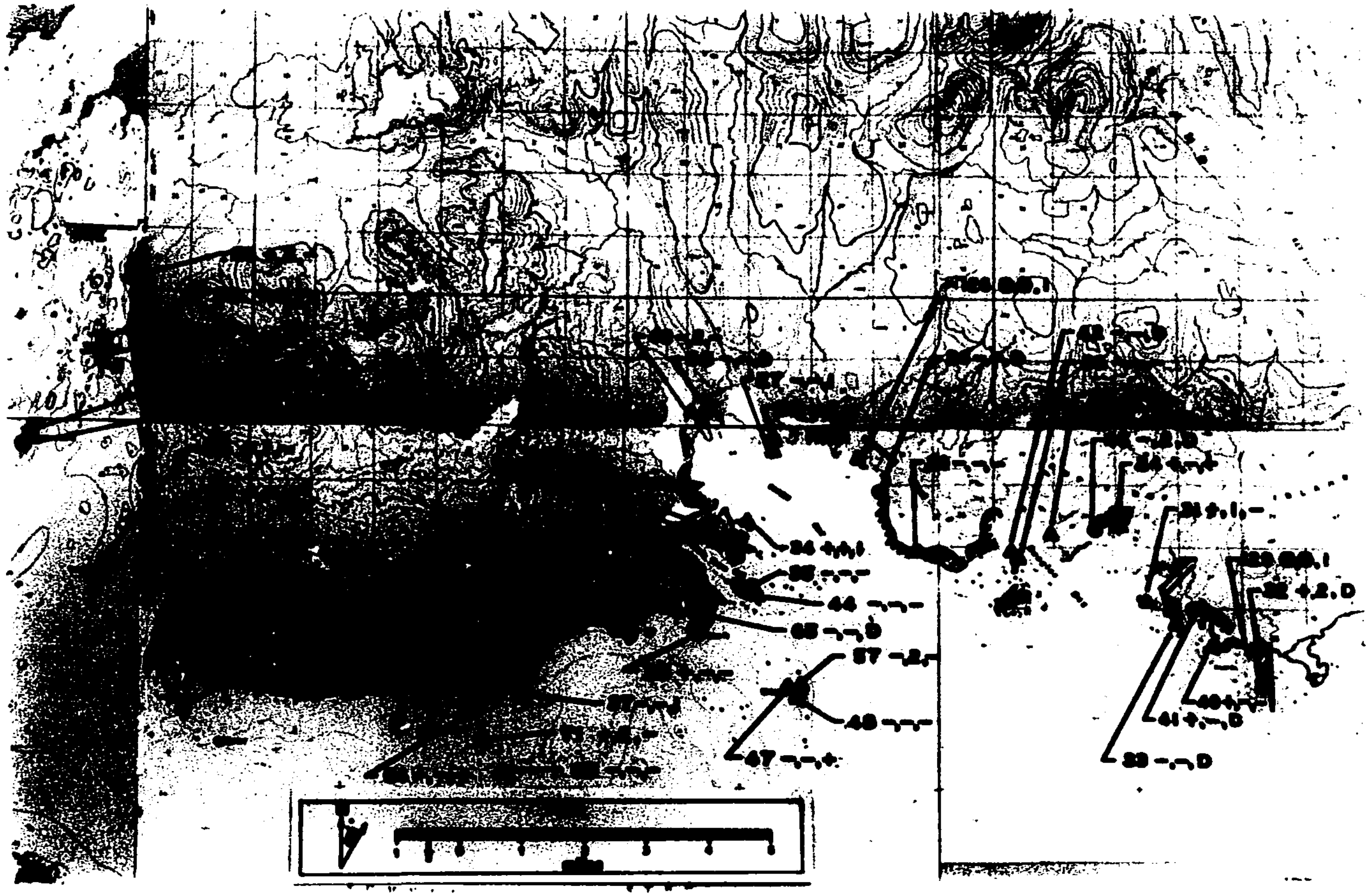
— inactive

⬢ not surveyed

D destroyed

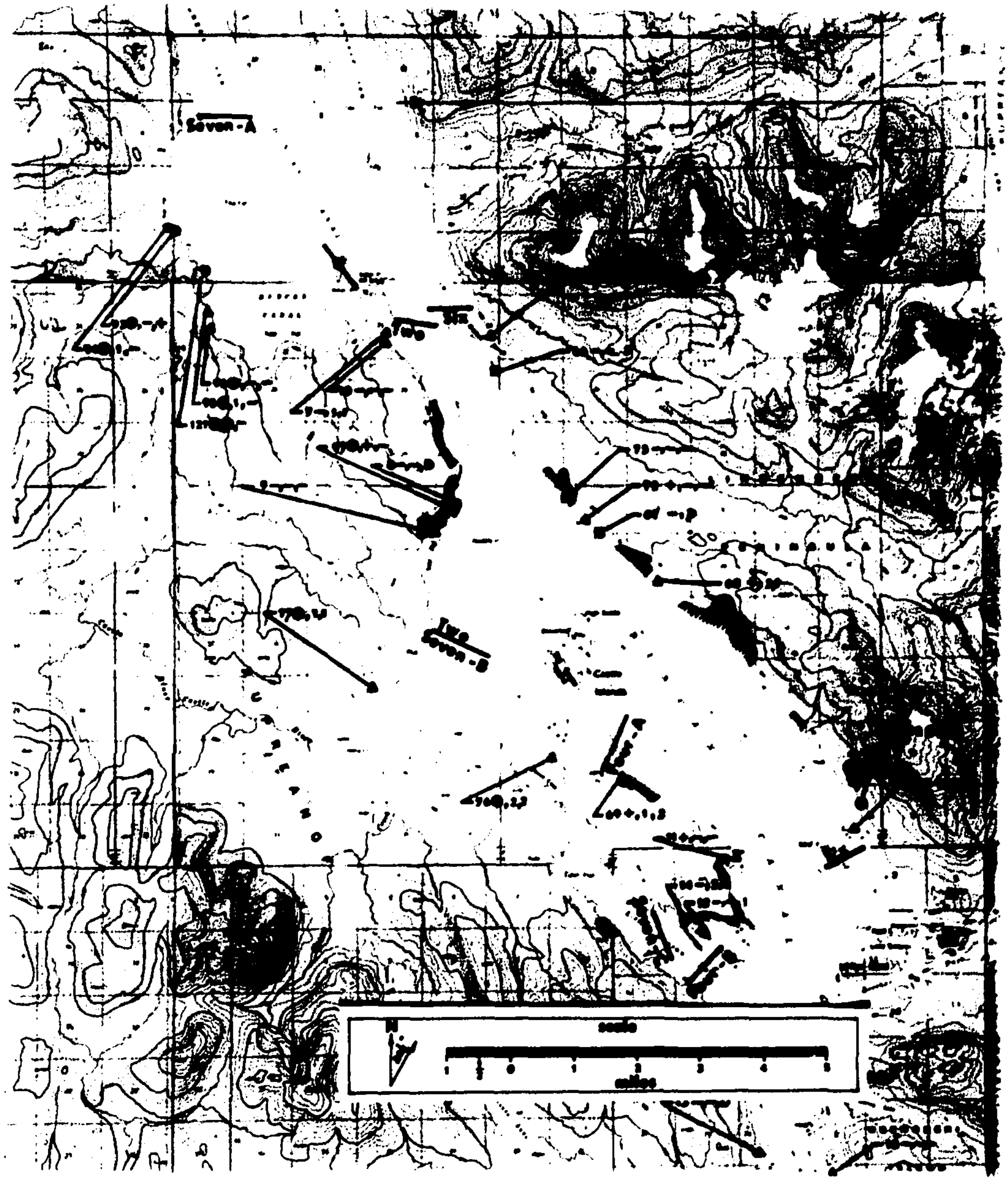
Map 1. The study area

Map from U.S. Geological Survey, Sumdum, 1961, and Petersburg, 1961, Alaska.



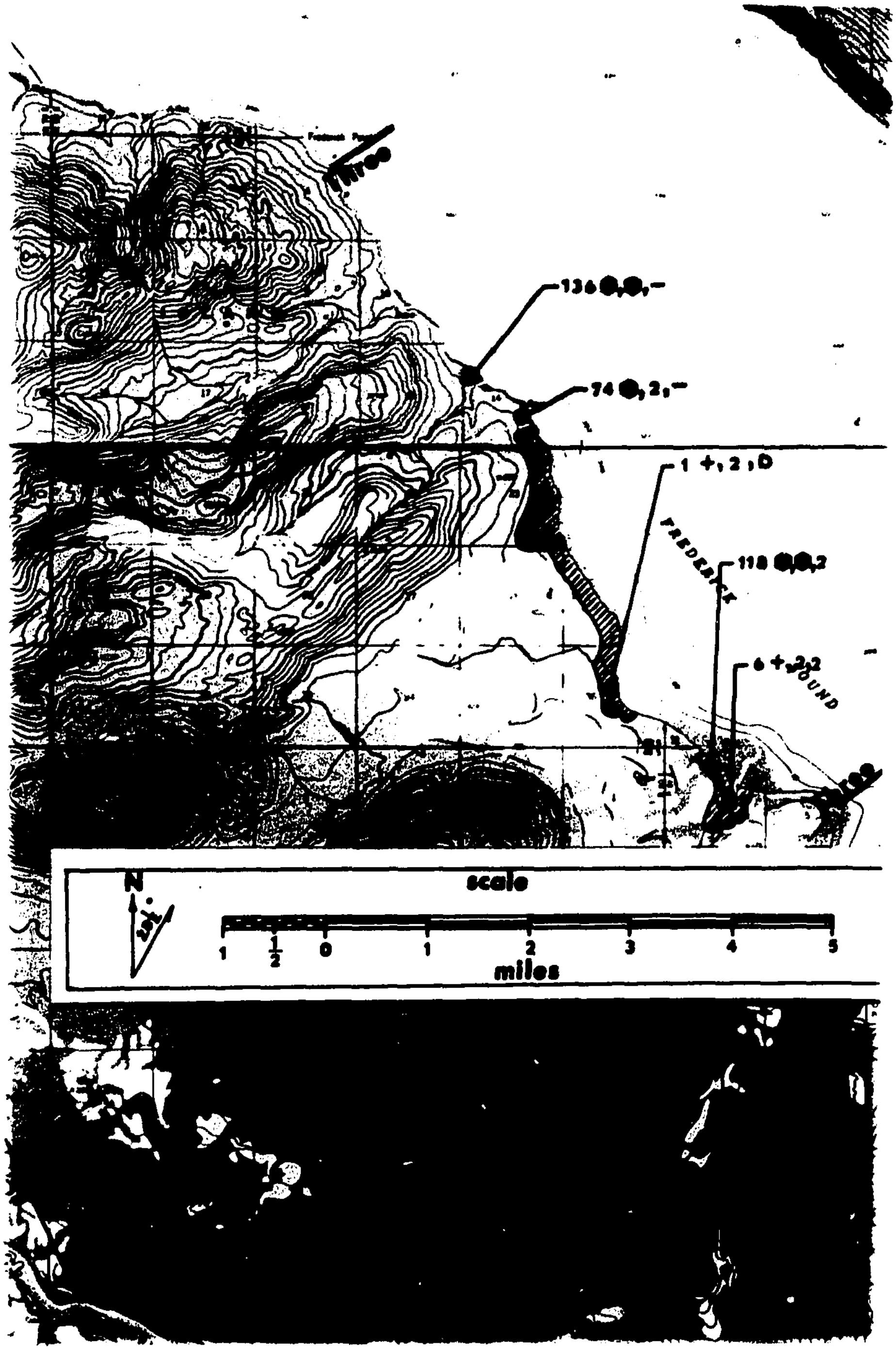
Map 2. Plot one

Map from U.S. Geological Survey, Petersburg (B-4, B-5, B-6, C-4, C-5, and C-6), Alaska.



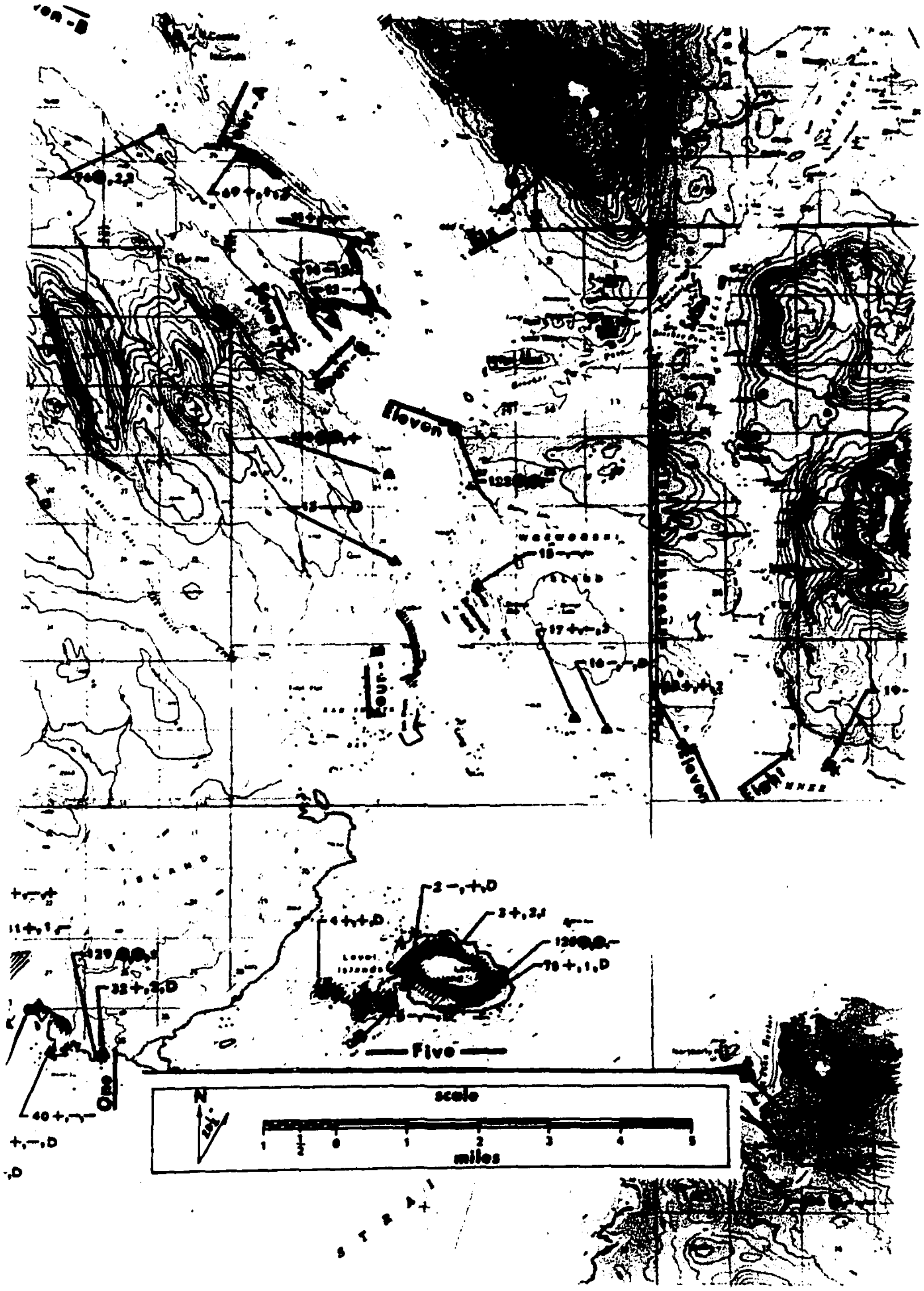
Map 3. Plots two, six, and seven

Map from U.S. Geological Survey, Petersburg (C-4, C-5, D-4, and D-5), Alaska.



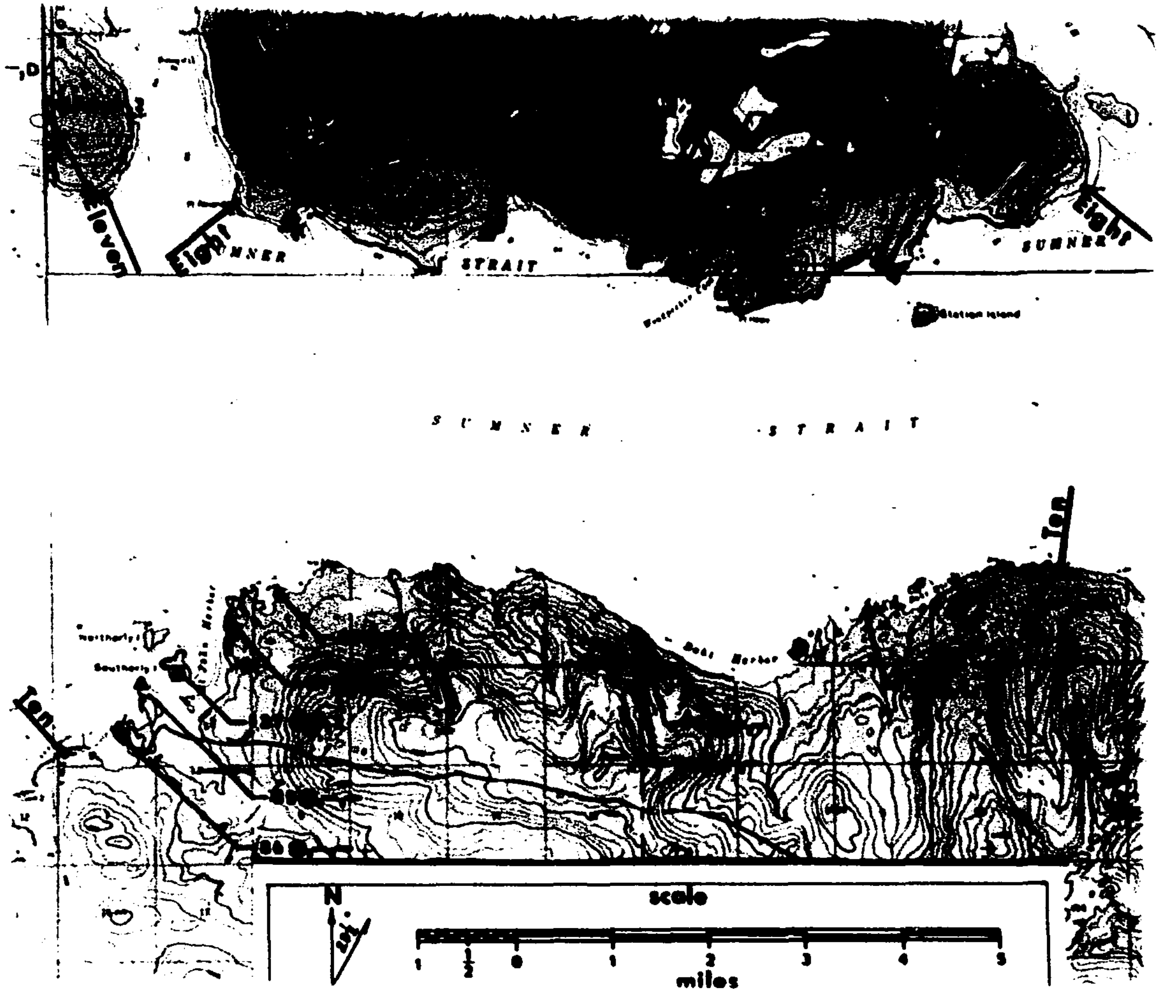
Map 4. Plot three

Map from U.S. Geological Survey, Petersburg (C-3 and D-3), Alaska.



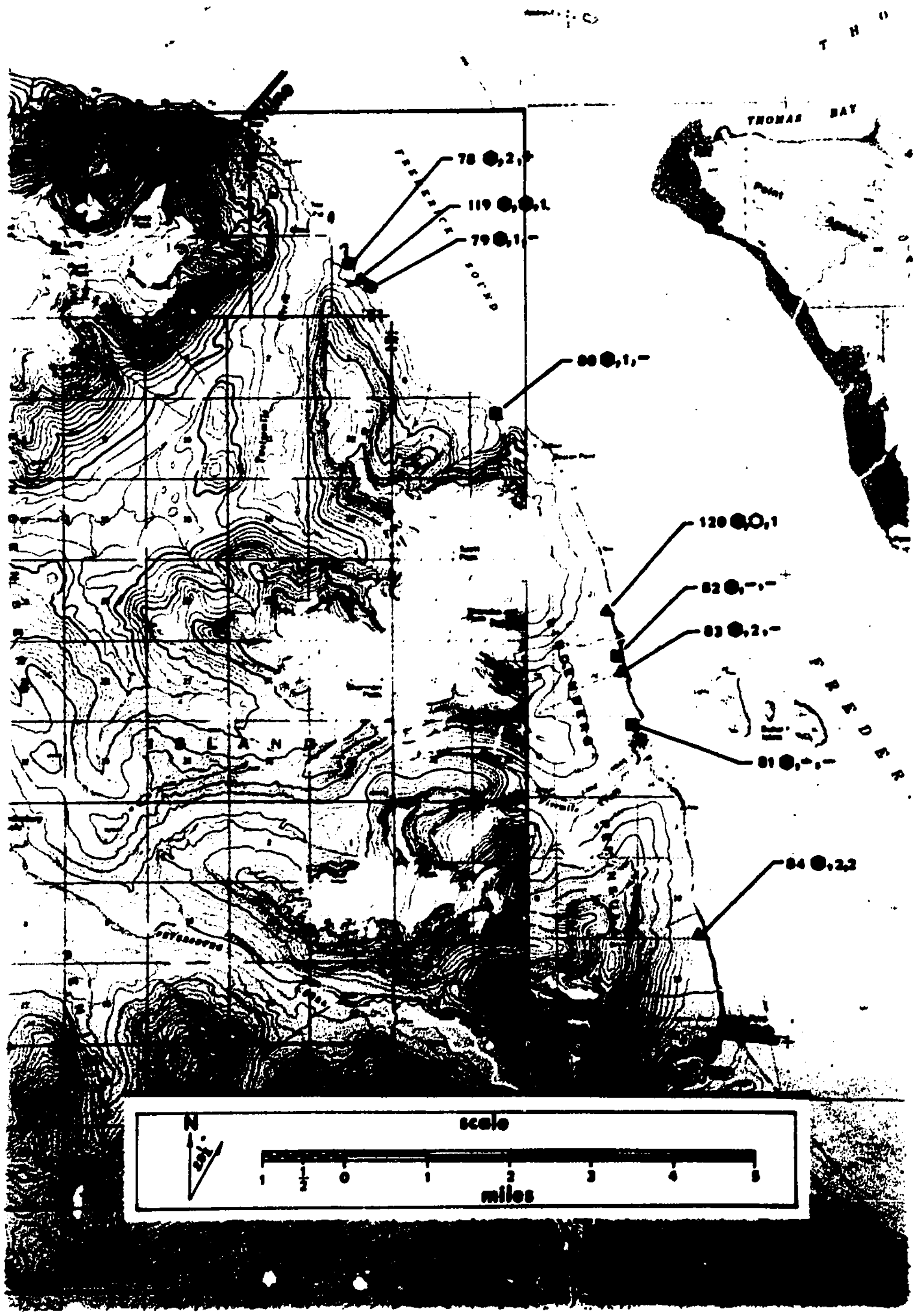
Map 5. Plots four, five, and eleven

Map from U.S. Geological Survey, Petersburg (B-3, B-4, C-3, and C-4), Alaska.



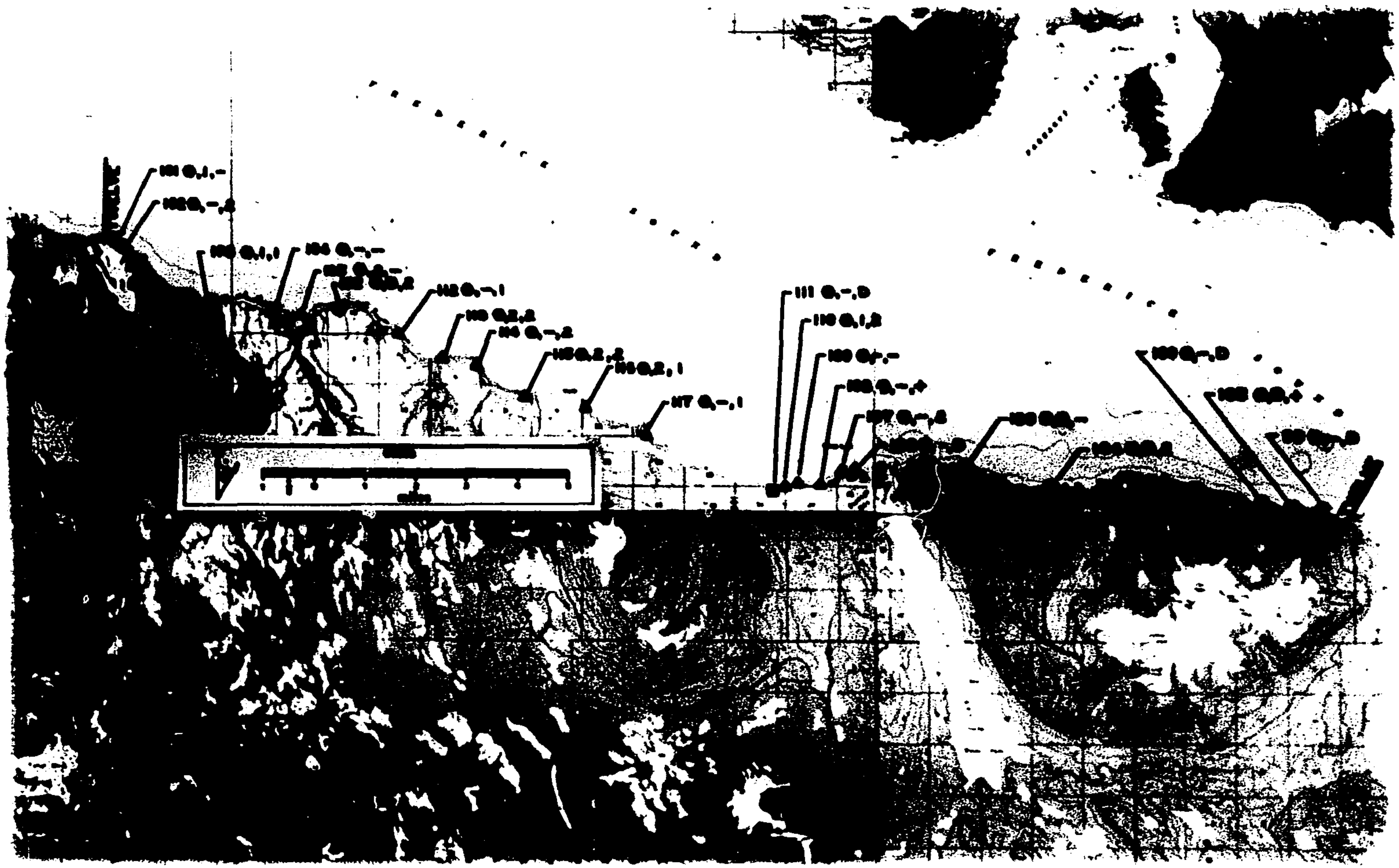
Map 6. Plots eight and ten

Map from U.S. Geological Survey, Petersburg (B-3 and C-3), Alaska.



Map 7. Plot nine

Map from U.S. Geological Survey, Petersburg (D-3 and D-4) and Sumdum (A-3 and A-4), Alaska.



Map 8. Plot twelve

Map from U.S. Geological Survey, Petersburg (D-4, D-5, and D-6) and Sumdum (A-4, A-5, and A-6), Alaska.

APPENDIX III

NEST DENSITY

Table III 27 presents nest density data for all nests located during the study, and Tables III 28, III 29, and III 30 present the densities of active nests during 1967, 1968, and 1969, respectively.

Table III 27. Nest Density - All Nests

Plot Number	Number of Nests	Miles of Beach	Nests Per Beach Mile	Beach Miles Per Nest
1	46	53.00	0.87	1.15
2	5	5.75	0.87	1.15
3	5	9.75	0.51	1.95
4	6	16.25	0.37	2.71
5	6	8.65	0.69	1.44
6	8	13.50	0.59	1.69
7	7	34.25	0.24	4.90
8	8	12.20	0.66	1.53
9	9	14.50	0.62	1.63
10	8	19.00	0.42	2.38
11	5	9.20	0.54	1.84
12	23	28.50	0.81	1.24
Total	136	224.30	0.60	1.65

Table III 28. Nest Density - Active Nests 1967

Plot Number	Active Nests	Active Nests Per Beach Mile	Beach Miles Per Active Nest
1	14	0.26	3.78
2	0	0.00	0.00
3	2	0.21	4.88
4	2	0.21	8.12
5	2	0.23	4.32
6	2	0.15	6.75
7	Not Surveyed Until 1968		
8	2	0.16	6.10
9	Not Surveyed Until 1968		
10	Not Surveyed Until 1968		
11	2	0.22	4.60
12	Not Surveyed Until 1968		
Total	26	0.20	4.94

Table III 29. Nest Density - Active Nests 1968

Plot Number	Active Nests	Active Nests Per Beach Mile	Beach Miles Per Active Nest
1	15	0.28	3.54
2	2	0.35	2.88
3	3	0.31	3.25
4	2	0.12	8.12
5	4	0.46	2.16
6	3	0.22	4.50
7	4	0.12	8.57
8	2	0.16	6.10
9	5	0.34	2.90
10	3	0.16	6.34
11	1	0.11	9.20
12	7	0.25	4.07
Total	51	0.23	4.40

Table III 30. Nest Density - Active Nests 1969

Plot Number	Active Nests	Active Nests Per Beach Mile	Beach Miles Per Active Nest
1	9	0.17	5.89
2	1	0.17	5.75
3	2	0.21	4.88
4	4	0.25	4.06
5	1	0.12	8.65
6	3	0.22	4.50
7	3	0.09	11.42
8	3	0.25	4.07
9	3	0.21	4.84
10	2	0.11	9.50
11	2	0.22	4.60
12	13	0.46	2.19
Total	46	0.20	4.89

APPENDIX IV

NEST STATUS AND PRODUCTION

Table IV 31. Nest Status and Production

Nest Number	YEAR 1967	1968	1969
1	+	2	D
2	-	+	D
3	+	2	1
4	+	+	D
5	-	-	D
6	+	2	2
7	-	1	1
8	-	-	D
9	-	-	-
10	-	-	-
11	+	-	-
12	-	-	1
13	-	-	D
14	-	2	2
15	-	-	-
16	-	-	D
17	+	-	2
18	+	+	2
19	-	-	+
20	2	-	D
21	-	2	1
22	+	2	-
23	-	-	-
24	+	-	+
25	-	-	-
26	-	-	D
27	-	-	1
28	-	2	-
29	+	2	-
30	-	-	-
31	+	1	-
32	+	2	D
33	-	-	D
34	+	+	1
35	-	-	-
36	+	-	-
37	-	-	1
38	-	-	D
39	-	-	-
40	+	-	-
41	+	-	D
42	-	-	D
43	-	2	-
44	-	-	-
45	-	-	-
46	-	2	D
47	-	-	+
48	-	-	-
49	-	-	+
50	-	-	D
51	-	-	-
52	-	+	-
53	-	-	-
54	+	1	-
55	-	-	-
56	+	2	-
57	-	2	-
58	+	2	-
59	-	-	+
60	+	2	-
61	-	D	
62	1	-	1
63	-	-	-
64	-	-	-
65	-	-	D
66	-	-	2
67	-	D	
68	+	2	1
69	+	1	2
70	+	1	D
71	-	2	-
72	+	-	-
73	-	-	-
74	+	2	-
75	+	1	D
76		2	2
77		1	1
78		2	+
79		1	-
80		1	-
81		-	-
82		-	-
83		2	-
84		2	2
85		-	-
86		-	-

Table IV 31. Contd.

Nest Number	YEAR 1967	1968	1969
87		-	-
88		2	-
89		+	-
90		-	-
91		1	+
92		2	-
93		-	+
94		1	-
95		1	-
96		-	-
97		+	-
98		+	-
99		-	D
100		-	D
101		1	-
102		-	2
103		1	1
104		-	-
105		2	-
106		-	D
107		-	2
108		-	+
109		-	-
110		1	2
111		-	D
112		-	1
113		2	2
114		-	2
115		2	2
116		2	1
117		-	1
118			2

Nest Number	YEAR 1967	1968	1969
119			1
120			1
121			-
122			-
123			1
124			-
125			-
126			-
127			2
128			-
129			1
130			+
131			2
132			2
133			-
134			2
135			+
136			-

\+ Active, Production Unknown
\- Inactive
D Destroyed
Numeral Equals Number of Eaglets Counted

APPENDIX V

DISTANCES BETWEEN NESTS

Table V 32. Distance Between Adjacent Nests by Plot (Yards)

ALL NESTS INCLUDED - PLOT ONE

Nest No.	Straight Line	Shore-line	Nest No.(Contd)	Straight Line	Shore-line
56-(58/59)	2,200	NA SI	47-57	110	220
58-59	55	55	47-48	220	440
(58/59)-60	3,080	NA II	48-57	110	165
(58/59)-61	3,300	NA II	(35/44)-(29/45)	2,310	NA IS
60-61	220	440	(35/44)-34	2,090	NA II
(60/61)-(53/54)	4,290	NA II	(29/45)-34	1,320	NA IS
53-54	165	220	29-45	165	165
(53/54)-70	1,595	NA IS	34-43	3,520	NA IS
70-52	1,265	3,080	34-38	3,355	NA IS
52-51	495	550	38-(27/28)	2,200	3,080
51-62	1,265	1,760	(27/28)-126	2,365	3,080
62-55	5,940	NA II	(27/28)-26	3,245	4,455
55-50	1,100	NA IS	126-26	1,210	1,320
50-49	1,540	1,760	26-30	1,980	2,424
50-64	1,435	NA SI	30-(39/42)	2,695	NA SI
64-49	220	NA SI	39-42	110	220
64-71	935	NA II	(39/42)-25	1,100	NA IS
71-55	2,420	NA II	25-46	1,210	2,310
55-63	3,190	NA II	46-24	825	1,540
71-63	1,045	NA II	24-31	2,200	7,700
49-37	1,430	1,760	31-33	1,045	2,420
71-37	1,705	NA IS	33-41	660	4,180
63-37	2,200	NA IS	33-40	1,210	NA SI
37-65	4,785	5,720	41-40	1,155	NA SI
65-36	990	NA IS	40-(129/32)	1,265	NA IS
36-(35/44)	1,980	NA II	32-129	110	165
36-(47/48/57)	3,190	NA II	31-41	1,375	6,600
(35/44)-(47/48/57)	2,970	NA II	36-(29/45)	2,970	5,280
35-44	165	NA II	43-38	495	550
Total				97,845	61,659
Mean				1,686	2,202

Table V 32. Contd.

Plot	Nest Numbers	ALL NESTS INCLUDED Straight Line	Shoreline
2	7-10	110	110
	(7/10)-(8/97)	5,115	5,610
	8-97	110	220
	(8/97)-9	770	880
Total		6,105	6,820
Mean		1,526	1,705
3	136-74	1,100	1,320
	74-1	5,060	5,500
	1-118	2,200	2,420
	118-6	220	220
Total		8,580	9,460
Mean		2,145	2,365
4	69-11	3,960	4,312
	11-12	2,200	5,720
	12-14	528	1,056
	14-130	4,565	NA OS
Total		11,253	11,088
Mean		2,813	3,696
5	3-125	1,320	1,408
	3-75	1,408	1,760
	3-2	1,496	2,904
	2-125	2,376	3,256
	2-75	2,200	2,904
	2-4	2,200	NA II
	2-5	1,804	NA II
	75-125	308	352
	4-5	1,672	NA II
Total		14,784	12,584
Mean		1,643	2,097

Table V 32. Contd.

Plot	Nest Numbers	ALL NESTS INCLUDED Straight Line	Shoreline
6	92-(7/10)	2,860	NA OS
	92-66	968	4,840
	66-(7/10)	3,135	NA OS
	66-73	3,960	4,488
	73-72	616	660
	72-67	792	880
	67-68	1,848	1,980
	68-123	8,448	9,020
	123-98	792	880
Total	. . . .	23,419	22,748
Mean	. . . .	2,602	3,250
7	94-93	88	132
	(94/93)-121	1,540	2,640
	121-95	1,144	1,584
	95-96	440	616
	(95/96)-(7/10)	4,750	9,240
	77-9	4,750	9,240
	77-76	5,280	12,320
	76-69	1,892	2,640
Total	. . . .	19,884	38,412
Mean	. . . .	2,436	4,802
8	19-20	3,520	4,752
	20-21	264	440
	21-23	2,552	3,344
	23-131	616	704
	131-124	484	528
	124-(22/128)	3,344	5,984
	22-128	88	88
Total	. . . .	10,868	15,840
Mean	. . . .	1,553	2,263

Table V 32. Contd.

Plot	Nest Numbers	ALL NESTS INCLUDED Straight Line	Shoreline
9	78-(79/119)	528	792
	(119/79)-80	4,048	4,664
	80-120	4,928	5,280
	120-82	880	968
	82-83	396	440
	83-81	1,232	1,496
	81-84	4,752	5,720
	79-119	88	88
Total	. . . .	16,940	19,360
Mean	. . . .	2,106	2,431
10	86-85	1,056	2,200
	85-127	704	NA II
	127-87	1,232	NA IS
	87-88	1,056	2,288
	88-89	6,424	7,568
	89-90	440	528
	90-91	3,960	5,808
Total	. . . .	14,872	18,392
Mean	. . . .	2,125	3,678
11	122-15	4,048	5,280
	15-17	4,136	6,688
	17-16	792	968
	16-18	2,024	2,288
Total	. . . .	11,000	15,224
Mean	. . . .	2,750	3,806

Table V 32. Contd.

Plot	Nest Numbers	ALL NESTS INCLUDED Straight Line	Shoreline
12	101-102	132	176
	102-103	3,608	3,960
	103-104	2,244	2,552
	104-105	968	1,100
	105-132	1,320	1,408
	132-112	2,200	2,640
	112-113	1,848	2,376
	113-114	1,100	1,232
	114-115	2,024	2,288
	115-116	2,112	2,552
	116-117	2,376	2,728
	117-111	4,928	5,456
	111-110	352	396
	110-109	352	440
	109-108	792	880
	108-107	836	968
	107-106	440	528
	106-133	3,784	4,664
	133-134	2,992	3,168
	134-100	7,304	9,504
	100-135	968	1,056
	135-99	1,056	1,320
Total		43,736	51,392
Mean		1,988	2,336

Table V 33. Distance Between Adjacent Active Nests by Year (Yards)

ACTIVE NESTS - PLOT ONE								
1967			1968			1969		
Nest No.	Straight Line	Shore-line	Nest No.	Straight Line	Shore-line	Nest No.	Straight Line	Shore-line
56/58	2,200	NA SI	56/58	2,200	NA SI	59/62	9,900	16,280
58/60	3,080	NA II	58/60	3,080	NA II	62/49	8,140	9,680
60/54	4,290	NA II	60/54	4,290	NA II	49/37	1,430	1,760
54/70	1,595	NA II	54/70	1,595	NA II	37/47	7,590	NA SI
70/62	2,970	5,720	70/52	1,265	3,080	47/34	4,950	NA II
62/36	14,520	17,380	52/71	9,460	12,320	34/27	2,255	NA IS
36/29	2,860	5,280	71/57	8,800	NA II	27/24	10,120	19,360
29/34	1,320	NA SI	57/29	5,170	NA II	24/129	5,115	17,380
34/24	10,560	NA IS	57/34	4,950	NA II			
24/31	2,200	7,700	29/34	1,320	NA IS			
31/41	1,375	6,600	34/43	3,520	NA IS			
41/40	1,210	NA SI	43/28	2,530	3,630			
40/32	1,265	NA IS	28/46	9,224	17,380			
			46/31	2,430	9,240			
			31/32	3,465	9,680			
Total	49,445	42,680	Total	63,299	55,330	Total	49,500	64,460
Mean	3,803	8,536	Mean	4,220	9,222	Mean	6,183	12,892

Table V 33. Contd.

		ACTIVE NESTS					
		1967		1968		1969	
Plot No.	Nest No.	Straight Line	Shore-line	Straight Line	Shore-line	Straight Line	Shore-line
2	7/92			2,860	NA OS		
	7/97			5,115	5,610		
	7/66					3,135	NA OS
Total				7,975	5,610	3,135	
Mean				3,988	5,610	3,135	
3	1/6	2,640	2,860				
	74/1			5,060	5,500		
	1/6			2,640	2,860		
	118/6					220	220
Total		2,640	2,860	7,700	8,360	220	220
Mean		2,640	2,860	3,850	4,180	220	220
4	69/11	3,960	4,312				
	69/14			4,455	11,088		
	69/76			1,892	2,640		
	69/14					4,455	11,088
	69/76					1,892	2,640
	14/12					528	1,056
	12/130					4,136	NA OS
Total		3,960	4,312	6,347	13,728	11,011	14,784
Mean		3,960	4,312	3,174	6,864	2,753	4,928

Table V 33. Contd.

		ACTIVE NESTS					
		1967		1968		1969	
Plot No.	Nest No.	Straight Line	Shore-line	Straight Line	Shore-line	Straight Line	Shore-line
5	3/4	3,608	NA II				
	3/4			3,608	NA II		
	3/2			1,496	2,904		
	3/75			1,408	1,760		
	2/75			2,200	2,904		
Total		3,608		8,712	7,568		
Mean		3,608		2,178	2,523		
6	72/68	2,728	2,860				
	92/7			2,860	NA OS		
	92/68			8,096	12,848		
	68/98			8,888	9,900		
	66/7					3,135	NA OS
	66/68					7,260	8,008
	68/123					8,448	9,020
Total		2,728	2,860	19,844	22,748	18,843	17,028
Mean		2,728	2,860	6,615	11,374	6,281	8,514

Table V 33. Contd.

Plot No.	Nest No.	1967 Straight Line	1967 Shore-line	1968 Straight Line	1968 Shore-line	1969 Straight Line	1969 Shore-line
		ACTIVE NESTS					
7	94/95			2,552	4,224		
	95/7			4,750	9,240		
	77/76			5,280	12,320	5,280	12,320
	93/7					6,424	13,464
Total				12,582	25,784	11,704	25,784
Mean				4,194	8,595	5,852	12,892
8	20/22	7,128	11,000				
	21/22			6,952	10,560		
	19/21					3,740	5,192
	21/131					3,300	4,048
Total		7,128	11,000	6,952	10,560	7,040	9,240
Mean		7,128	11,000	6,952	10,560	3,520	4,620

Table V 33. Contd.

		ACTIVE NESTS					
		1967		1968		1969	
Plot No.	Nest No.	Straight Line	Shore-line	Straight Line	Shore-line	Straight Line	Shore-line
9	78/79			528	792		
	79/80			4,048	4,664		
	80/83			6,248	6,600		
	83/84			5,984	7,216		
	78/119					528	792
	119/120					9,064	9,964
	120/84					7,392	8,536
Total				16,808	19,272	16,984	19,292
Mean				4,202	4,818	5,661	6,431
10	88/89			6,424	7,568		
	89/91			4,224	6,336		
	91/127					12,408	16,720
Total				10,648	13,904	12,408	16,720
Mean				5,324	6,952	12,408	16,720
11	17/18	2,816	3,256			2,816	3,256
Total		2,816	3,256			2,816	3,256
Mean		2,816	3,256			2,816	3,256

Table V 33. Contd.

Plot No.	Nest No.	ACTIVE NESTS 1967 Straight Line	1967 Shore-line	1968 Straight Line	1968 Shore-line	1969 Straight Line	1969 Shore-line
12	101/103			3,696	4,136		
	103/105			3,256	3,652		
	105/113			5,048	6,424		
	113/115			2,728	3,520		
	115/116			2,112	2,552	2,112	2,552
	116/110			7,568	8,580	7,568	8,580
	102/103					3,608	3,960
	103/132					4,488	5,060
	132/112					2,200	2,640
	112/113					1,848	2,376
	113/114					1,320	1,232
	114/115					2,024	2,288
	110/108					1,144	1,320
	108/107					836	968
	107/134					7,216	8,360
	134/135					8,184	10,566
Total				24,408	28,864	42,548	49,902
Mean				4,068	4,811	3,546	4,158

APPENDIX VI

MISCELLANEOUS NEST SITE CHARACTERISTICS

Table VI 34. Nest Tree Species, Dominance Class, Tree Height, Nest Height, and Per cent of Trunk Above Nest for 136 Nests.

		Nest Tree Species					Dominance Class						
Nest Number	Plot Number	Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominant	Codominant	Intermediate	Suppressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
1	3				*			*			106	85	25
2	5	*						*			100	83	17
3	5	*						*			80	80	0
4	5	*					*				115	115	0
5	5	*					*				133	105	21
6	3	*					*				165	123	26
7	2	*						*			110	107	3
8	2		*					*			95	92	3
9	2	*					*				107	83	22
10	2	*					*				135	107	21
11	4	*					*				100	70	30
12	4	*						*			125	80	36
13	4	*					*				145	111	23
14	4		*				*				122	106	13
15	11	*						*			100	74	26
16	11	*						*			125	115	8
17A	11	*						*			111	95	14
17B												87	22
18	11	*					*				145	104	28
19	8	*					*				125	112	10

Table VI 34. Contd.

Nest Number	Plot Number	Nest Tree Species: Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominance Class: Dominant	Codominant	Intermediate	Suppressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
20	8	*					*				147	128	13
21	8	*						*			114	103	10
22	8	*					*				106	92	13
23	8			*			*				106	92	13
24	1	*					*				150	128	15
25	1	*							*		128	103	20
26	1		*				*				150	120	20
27	1	*						*			117	112	4
28	1	*					*				144	118	18
29	1	*					*				144	96	33
30	1	*					*				147	126	14
31	1	*						*			117	103	12
32	1	*						*			98	87	11
33	1	*						*			122	63	48
34	1	*					*				141	99	30
35	1	*						*			99	74	25
36	1	*					*				136	85	38
37	1	*					*				135	110	18
38	1	*						*			125	80	36
39	1	*					*				104	90	14
40	1	*							*		113	71	37

Table VI 34. Contd.

		Nest Tree Species					Dominance Class						
Nest Number	Plot Number	Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominant	Codominant	Intermediate	Suppressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
41	1		*					*			106	83	22
42	1	*					*				81	79	2
43	1	*						*			138	133	4
44	1	*					*				93	80	14
45	1	*					*				134	86	36
46	1		*					*			120	97	19
47	1	*					*				130	110	15
48	1	*						*			118	100	15
49	1	*						*			95	85	10
50	1	*					*				155	95	39
51A	1	*					*				125	105	16
51B												95	24
52	1	*					*				140	125	11
53	1				*				*		33	30	9
54	1		*					*			135	135	0
55	1			*			*				110	87	21
56	1	*						*			115	80	30
57	1	*							*		90	85	6
58	1	*					*				125	100	20
59	1	*					*				128	98	23
60	1	*						*			130	90	31
61	1					*					not relocated for measurement		

Table VI 34. Contd.

Nest Number	Plot Number	Nest Tree Species: Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominance Class: Dominant	Codominant	Intermediate	Suppressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
62	1	*							*		106	83	22
63	1	*					*				117	107	9
64	1	*						*			120	93	22
65	1	*						*			125	110	12
66	6				*				*		120	105	12
67	6				*			*			135	105	22
68	6	*					*				148	120	19
69	4	*						*			138	121	12
70	1	*						*			70	60	14
71	1	*							*		90	84	7
72	6	*							*		85	70	18
73	6				*		*				110	86	22
74	3		*				*				164	114	30
75	5	*						*			150	88	41
76	7	*						*			136	136	0
77	7	*						*			133	96	28
78	9		*					*			93	86	8
79	9		*					*			58	58	0
80	9				*			*			62	52	16
81	9				*				*		79	79	0
82	9				*			*			125	89	29
83	9	*					*				172	102	41

Table VI 34. Contd.

		Nest Tree Species					Dominance Class						
Nest Number	Plot Number	Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominant	Codominant	Intermediate	Surpressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
84	9	*					*				167	127	24
85	10	*					*				95	65	32
86	10		*						*		60	60	0
87	10	*						*			122	103	16
88	10		*				*				113	83	27
89	10	*					*				155	137	12
90	10	*					*				170	137	19
91	10	*					*				126	93	26
92	6	*						*			106	84	21
93	7		*					*			102	76	26
94	7		*						*		83	62	25
95	7	*					*				101	77	24
96	7	*						*			121	107	12
97	2	*					*				138	113	18
98	6	*					*				102	90	12
99	12		*				*				117	98	16
100	12		*						*		88	85	3
101	12	*					*				131	117	11
102	12	*					*				133	102	23
103	12	*						*			111	98	12
104	12	*						*			129	101	22

Table VI 34. Contd.

		Nest Tree Species					Dominance Class						
Nest Number	Plot Number	Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominant	Codominant	Intermediate	Surpressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
105	12	*							*		86	83	4
106	12	*					*				162	154	5
107	12	*					*				174	146	16
108	12	*					*				162	136	16
109	12	*					*				164	126	23
110	12	*						*			129	117	9
111	12				*				*		108	108	0
112	12	*						*			118	116	2
113	12	*						*			121	105	13
114	12	*						*			118	96	19
115	12	*						*			133	115	14
116	12	*					*				141	115	18
117	12	*						*			128	114	11
118	3	*					*				142	113	20
119	9	*							*		102	84	18
120	9	*					*				116	98	16
121	7		*					*			90	76	16
122	11					*				not relocated for measurement			
123	6					*				not relocated for measurement			
124	8		*						*		60	55	8
125	5	*						*			80	70	12
126	1	*							*		70	70	0

Table VI 34. Contd.

		Nest Tree Species					Dominance Class						
Nest Number	Plot Number	Sitka Spruce	Western Hemlock	Cedar	Dead Trunk	Unknown	Dominant	Codominant	Intermediate	Surpressed	Tree Height	Nest Height	Per cent of Trunk Above Nest
127	10		*				*				65	65	0
128	8	*					*				140	140	0
129	1	*						*			70	60	14
130	4	*							*		85	70	18
131	8	*						*			95	95	0
132	12					*				not relocated for measurement			
133	12					*				not relocated for measurement			
134	12					*				not relocated for measurement			
135	12					*				not relocated for measurement			
136	3					*				not relocated for measurement			
Totals		99	18	2	9	8	58	52	18	0	15,053	12,578	
Average											118	97	18
Per cent of Total		73	13	1	7	6	45	41	14	0			

APPENDIX VII

DISTANCE FROM NEST TREE TO SHORE

Table VII 35. Distance From Nest Tree to Shore

Nest No.	Distance (feet)	Nest No.	Distance (feet)	Nest No.	Distance (feet)
1	102	47	250	93	80
2	93	48	77	94	155
3	95	49	74	95	116
4	86	50	50	96	210
5	146	51	62	97	30
6	180	52	115	98	70
7	24	53	15	99	62
8	68	54	100	100	65
9	20	55	55	101	125
10	24	56	165	102	86
11	30	57	35	103	48
12	69	58	130	104	122
13	141	59	200	105	115
14	93	60	105	106	38
15	128	61		107	110
16	165	62	125	108	38
17	100	63	20	109	116
18	350	64	75	110	28
19	83	65	85	111	145
20	62	66	110	112	58
21	50	67	55	113	68
22	112	68	125	114	55
23	290	69	100	115	75
24	155	70	20	116	75
25	168	71	65	117	63
26	137	72	30	118	245
27	79	73	125	119	45
28	238	74	119	120	78
29	50	75	128	121	35
30	235	76	35	122	
31	167	77	67	123	
32	97	78	85	124	
33	150	79	56	125	
34	165	80	85	126	25
35	86	81	145	127	70
36	62	82	175	128	
37	250	83	195	129	20
38	123	84	108	130	150
39	125	85	90	131	350
40	32	86	125	132	
41	145	87	275	133	
42	125	88	125	134	
43	163	89	125	135	

Table VII 35. Contd.

Nest No.	Distance (feet)	Nest No.	Distance (feet)	Nest No.	Distance (feet)
44	70	90	70	136	
45	30	91	200		
46	135	92	200	Total	(126)13,495
				Mean	107
				Range	15 -350

APPENDIX VIII

EXPOSED BEACH AT LOW TIDE

Table VIII 36. Exposed Beach at Low Tide by Beach Type (Yards)

Nest Number	One	Two	Three	Four	Five	Six
			BEACH TYPE			
1						440
2		80				
3		77				
4			73			
5		66				
6						800
7					50	
8				163		
9						250
10					50	
11	0					
12						1,100
13						440
14						260
15			60			
16	15					
17	10					
18		35				
19			25			
20			30			
21			30			
22			30			
23	0					
24			NE			
25				113		
26				30		
27				NE		
28				NE		
29				33		
30		57				
31						200
32	12					
33			37			
34				210		
35			113			
36			40			
37	17					
38						528
39		120				
40	10					
41	0					

Table VIII 36. Contd.

Nest Number	One	Two	Three	Four	Five	Six
			BEACH TYPE			
42			30			
43						528
44		110				
45				17		
46				23		
47			30			
48		175				
49				125		
50				93		
51		67				
52		50				
53	16					
54			28			
55	5					
56			107			
57		60				
58				87		
59		87				
60			143			
61			NE			
62			20			
63	10					
64	10					
65				17		
66					33	
67				NE		
68				175		
69			67			
70	10					
71	10					
72				33		
73				35		
74				40		
75		183				
76						440
77						2,640
78			100			
79			55			
80			30			
81					167	
82			35			
83			35			

Table VIII 36. Contd.

Nest Number	One	Two	Three	Four	Five	Six
			BEACH TYPE			
84				140		
85			25			
86			60			
87			50			
88						108
89			70			
90			68			
91	15					
92						200
93						2,288
94						2,288
95						2,904
96						3,168
97						200
98			NE			
99				28		
100			50			
101		27				
102		60				
103		133				
104		130				
105				NE		
106			113			
107				57		
108				57		
109			117			
110			97			
111			140			
112		170				
113		170				
114		120				
115				138		
116		170				
117		120				
118						800
119			100			
120	0					
121						2,112
122	0					
123						175
124	0					
125		110				

Table VIII 36. Contd.

Nest Number	BEACH TYPE One	Two	Three	Four	Five	Six
126				100		
127			NE			
128			30			
129		25				
130	NE					
131	0					
132		240				
133		NE				
134			50			
135			NE			
136			NE			
Total	140	2,642	2,088	1,714	300	21,869
Mean	7.4	105.7	61.4	81.6	75	1,041.4
Variance	40.69	11.45	1296.9	3447.4	3826	1,075,813.5
Standard Deviation	6.4	3.4	36.0	58.7	61.8	1037.2

NE = No Estimate

APPENDIX IX

RELATIONSHIP AMONG NEST SITE CHARACTERISTICS AND ACTIVITY OF NESTS

Table IX 37. Edge punch card analysis of nest site factors at 136 nests

	I Nests Inactive during majority of study 0/3; 0/2; 1/3 years (53 nests)		II Nests with trend undetermined 0/1; 1/1; 1/2 years (48 nests)		III Nests Active during majority of study 3/3; 2/3; 2/2 years (35 nests)		Overall Distribution (136 nests)	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Beach Types:								
Steep Ledge	8	15	6	12	3	9	17	12
Gentle Ledge	11	21	11	23	8	23	30	22
Large Rock	12	23	16	34	11	31	39	29
Gravel-Large Rock	12	23	6	12	6	17	24	18
Sand	3	5	0	0	1	3	4	3
Mud Flat	7	13	9	19	6	17	22	16
Tree Species:								
Sitka spruce	43	81	26	54	30	86	99	73
Western hemlock	3	6	11	23	4	11	18	13
Dead trunk	5	9	3	6	1	3	9	7
Cedar	2	4	0	0	0	0	2	1
Unknown	0	0	8	17	0	0	8	6
Islet nests	17	32	4	8	5	14	26	19
Eaglet Production per nest per year	1.75		1.56		1.59		1.69	

Table IX 37. Contd.

	I Nests Inactive during majority of study 0/3; 0/2; 1/3 years (53 nests)		II Nests with trend undetermined 0/1; 1/1; 1/2 years (48 nests)		III Nests Active during majority of study 3/3; 2/3; 2/2 years (35 nests)		Overall Distribution (136 nests)	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Distance from nest to shore: (feet)								
0 - 25	4	8	2	4	2	6	8	6
26 - 50	6	11	5	10	5	14	16	12
51 - 100	16	30	15	32	12	34	43	32
101 - 200	20	38	13	27	15	43	48	35
201 - 300	7	13	1	2	0	0	8	6
301 plus	0	0	1	2	1	3	2	1
not measured	0	0	11	23	0	0	11	8
Exposed beach at low tide: (yards)								
0 - 25	14	26	7	14	5	17	26	19
26 - 100	21	39	16	34	13	37	50	37
101 - 500	12	23	11	23	14	39	37	27
501 - 1000	2	4	1	2	1	3	4	3
1001 plus	2	4	4	8	1	4	7	5
not measured	2	4	9	19	1	3	12	9
Nests within Logged Plots	40	75	15	31	21	60	76	56

Table IX 37. Contd.

	I Nests Inactive during majority of study 0/3; 0/2; 1/3 years (40 nests in logged plots)		II Nests with trend undetermined 0/1; 1/1; 1/2 years (15 nests in logged plots)		III Nests Active during majority of study 3/3; 2/3; 2/2 years (21 nests in logged plots)		Overall Distribution (76 nests in logged plots)	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Proximity to logged area:								
within logged area	7	17	5	33	9	43	21	28
within 1/4 mile of logged area	12	30	1	7	5	24	18	24
between 1/4 and 1/2 mile of logged area	8	20	3	20	3	15	14	18
between 1/2 and 1 mile of logged area	7	17	3	20	2	9	12	16
greater than 1 mile from logged area	6	16	3	20	2	9	11	14